U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF ANIMAL INDUSTRY.

BULLETIN No. 1.

INVESTIGATIONS

INTO THE

NATURE, CAUSATION, AND PREVENTION

OF

TEXAS OR SOUTHERN CATTLE FEVER.

MADE UNDER THE DIRECTION OF DR. D. E. SALMON,
CHIEF OF THE BUREAU OF ANIMAL INDUSTRY,

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., February 6, 1893.

Sir: I have the honor to submit herewith a report covering "Investigations into the Nature, Causation, and Prevention of Texas or Southern Cattle Fever," which have been conducted under my direction by Drs. Theobald Smith and F. L. Kilborne, of this Bureau. These investigations have extended over a period of several years, and it is gratifying to be able to state that they have been successful in discovering the cause of the disease and the means by which it is transmitted.

In the whole list of diseases affecting the domesticated animals, there is none so peculiar in its character or so mysterious in its phenomena as was this one previous to these researches. The dissemination of the deadly contagion by apparently healthy cattle, and the harmlessness in general of the really sick animals were inexplicable by any facts which were furnished by the study of other diseases. Veterinarians who had not had an opportunity to observe this disease were skeptical in regard to the correctness of such conclusions, and some spoke of them as a "romance in pathology." These early observations have not only been confirmed, but the phenomena have been explained, and our knowledge placed upon a scientific basis.

It had long been believed by the cattle-raisers of the West that Texas fever was caused by the ticks which were carried and scattered everywhere by the Southern cattle; but scientists were incredulous, because they could not understand how the bite of these insects could produce such an acute disease, with destruction of the blood corpuscles and lesions of internal organs. It was not until the protozoal microörganism was discovered in the blood corpuscles, and its destructive effects were revealed, that the action of the ticks could be explained.

When the writer investigated the extent of the infected district he was strongly impressed with the fact, which then first became apparent, that this district almost exactly corresponded with the habitat of the suspected tick. This led to the experiments which demonstrated that ticks carried the infection, introduced it into the tissues of the susceptible cattle, and in that way produced the disease. We have to

deal, therefore, with a complicated infection, in which two very different kinds of parasites play an important part.

Another significant discovery, not less marvelous, is that the micro-örganism which constitutes the contagion of the disease is transmitted through the egg to the young tick, and it is this, and not the adult tick carried by the Southern cattle, which finds its way upon susceptible animals and causes the disease. In the absence of the tick, the disease is probably not communicable except by artificial inoculation.

The accompanying report gives all the details of the investigations referred to, and will be found of the greatest interest both to the cattle-owner desirous of preserving his animals from this dangerous malady, and to the scientist who wishes to know the various methods by which contagion may be distributed. The researches have been made with great care and thoroughness, and the gentlemen who have conducted them have shown perseverance and scientific ability of the highest order. Their work, as described in these pages, has for its foundation accurate scientific experiments, and, however unexpected may be the results, these may be relied upon as furnishing the basis for the true exposition of the disease.

Very respectfully,

D. E. Salmon,
Chief of Bureau.

Hon. J. M. Rusk,
Secretary.

LETTER OF SUBMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., November 15, 1892.

Sir: I have the honor to submit herewith a report on the nature, causation, and prevention of Texas cattle fever. The investigations upon which it is based have been carried on more or less continuously since 1888. That part of the work dealing with the intimate nature of the disease, its pathology and etiology, and the microscopical and bacteriological work involved in their elucidation was carried on by myself, at the experiment station and at the laboratory of the Division of Animal Pathology, while the field work at the experiment station, embracing the planning and arranging of the field experiments in general and those relating to the cattle ticks in particular, was carried on by F. L. Kilborne, B. V. S. Much assistance has been rendered by E. C. Schroeder, M. D. V., who, under my direction, did the major part of the work of estimating the blood corpuscles in the various cases of Texas fever, and who assisted at the post-mortem examinations from the latter half of the season of 1890 up to the present. Latterly S. D. Maynard, B. S., has also rendered some assistance in this work.

Much difficulty has been experienced in the proper arrangement of the subject-matter, owing to the large number of experiments which have been carried out and the various directions which the investigations had to take. The large amount of material which has accumulated had to be condensed and brought into a compact form. The plan adopted relegated the detailed history of the various cases into an appendix. By this means the report itself could be brought into a form which includes all the important results of the work fully discussed. The verification of these results must be sought for in the appendix under the individual cases. Such an arrangement occasionally demanded repetitions and cross references, since individual experiments have frequently borne fruit of several kinds which had to be brought into relation with several different subjects.

In the present report the old name, "Texas fever," has been used, since it is the name first given to the disease in the earlier publications and probably the one by which it is most readily recognized. The reten-

tion of this name does not, of course, imply any restriction of the disease to the State which bears its name, for it is now well known, largely owing to your investigations, that the entire southern belt of this country is equally responsible for it. The term "Southern cattle fever" is not much better, since it is now highly probable that this disease is not peculiar to our country, but exists in other countries situated as we are with reference to latitude. In fact it is hardly to be doubted that this malady exists along the Danube River, in the Balkan provinces, and in the southern territories of Africa. The time has not yet arrived, therefore, to give this disease a more scientific name worthy of its cosmopolitan character, and for this reason the old, familiar, and shorter appellation of "Texas fever" has been temporarily retained.

THEOBALD SMITH,
Chief of the Division of Animal Pathology.

DR. D E. SALMON,
Chief of the Bureau of Animal Industry.

NATURE, CAUSATION, AND PREVENTION OF TEXAS FEVER.

HISTORICAL REVIEW.

Up to the time at which these investigations were begun, a certain number of very important facts had already been ascertained and repeatedly confirmed concerning the nature of Texas or Southern cattle fever. There were also a number of theories in the field concerning the causation or etiology of this disease, based in part on investigation, in part on speculation.

Of those definitely ascertained facts, we may mention as the most important the one which traced the distribution of the infection to cattle brought from a large but well-defined territory, including most of the Southern States, into more northerly regions. The Southern cattle bearing the infection were, as a rule, free from any signs of disease. It was likewise settled that this infection was carried only during the warmer season of the year, and that in the depth of winter Southern cattle were harmless. It was also known that the infection was not communicated directly from Southern to Northern cattle, but that the ground over which the former passed was infected by them, and that the infection was transmitted thence to susceptible cattle. All that was necessary for the production of disease was the passage of Southern cattle over a given territory and the grazing of Northern cattle over the same or a portion of the same territory during the same season.

It was also discovered that Southern cattle, after remaining for a short time on Northern pastures, lost, in some mysterious way, the power to infect other pastures and were, for the remainder of their stay North, harmless. Again, cattle driven over a considerable distance lost, after a time on their way, the power to infect pastures. When pastures and trails had been passed over by Southern cattle, it was observed that the disease did not appear at once in the Northern cattle grazing on them, but that a certain period of not less than thirty days elapsed before the native cattle began to die. More curious even than these

facts, was the quite unanimous testimony of stock-owners who had had more or less experience with this disease, that native susceptible animals who had become diseased did not transmit the disease to other natives, and that they were harmless. We shall discuss this statement in detail, in connection with experiments made to test its accuracy.

If we turn our attention to the opposite aspect of this interesting series of facts which deals with the introduction of Northern cattle into Southern territory, we learn that such cattle may contract Southern cattle fever, and that it is only under considerable risks that Northern cattle can be introduced into what has been called the permanently infected territory.

These interesting facts about a mysterious disease were largely reasoned out by farmers and stock owners in their trying experience with it and were well known before 1868, when the disease began to arouse the attention of the Government, owing to its widespread devastations in the Northern States in that year. The historical record of the development of these ideas is therefore very meager. That Southern cattle in a state of health might bring destruction to Northern herds was observed late in the last century by Dr. Pease. A herd of cattle was driven in 1796 from South Carolina into Pennsylvania, where disease broke out in Lancaster county and other places. This disease was directly traced to the Southern herd by Dr. Pease, who made it the subject of an interesting communication and dwelt particularly upon the fact that the cattle bringing the disease were themselves in good health.

In 1868, Texan cattle shipped up the Mississippi River to Cairo and thence by rail into Illinois and Indiana early in June caused during the summer of that year enormous losses of cattle in these States. Moreover the East began to be aroused because Western cattle infected with the disease had been shipped eastward for beef and were dying of Texas fever on the way, in the New York stock yards and elsewhere. The question as to the effect of such diseased flesh upon human health was at that time entirely new and caused much uneasiness. The cattle commissioners of New York State and the board of health of New York City made a vigorous effort to check the importation of diseased cattle from the West, and to their efforts we owe much valuable information of this disease. During that year it was investigated by Dr. R. C. Stiles for the Metropolitan Board of Health and by John Gamgee and Drs. John S. Billings and Curtis for the National Government. Since then investigations have been made and published by Drs. D. E. Salmon and Detmers for the United States Department of Agriculture, and by Drs. Frank S. Billings, Paquin, Dinwiddie, and Francis for the experiment stations of certain States. These various reports will be again referred to under the special subjects to which their authors have given more or less attention.

Perhaps the most important and special contribution to the subject since the earlier investigations of 1868 is the determination of the boundary line of the permanently infected district by Dr. D. E. Salmon (5, 6, 7).* From what has already been stated it will be readily understood that this line marks the northern limit of the territory from which cattle may carry the infection into the territory north of this line. On the other hand to cross this line from north to south obviously places cattle in the position to contract Texas fever under favorable conditions. The investigations of Dr. Salmon have shown that this permanently infected area does not extend north of the 37th parallel of latitude excepting along the eastern slope of the country, where it extends halfway between the 38th and 39th parallel. The order of the Secretary of Agriculture issued February 26, 1892, puts the following States and Territories entirely within the permanently infected area: South Carolina, Georgia, Florida, Alabama, Mississippi, Arkansas, Louisiana, and Indian Territory. The following are crossed by the boundary line and are therefore not entirely within the infected area: Virginia, North Carolina, Tennessee, Oklahoma, and Texas. The line as at present defined begins at the Atlantic coast, passing westward on the 38th parallel, and follows the lower boundary of Maryland to the Potomac. It then passes westward across Virginia as far as the eastern slope of the Blue Ridge, which it follows in a southwesterly direction through North Carolina, thus exempting the cooler mountainous regions of these two States from permanent infection. It continues in a nearly westerly direction across the southern strip of western North Carolina and the southern portion of Tennessee. Across the Mississippi it follows the northern boundary of Arkansas and that of the Indian and Oklahoma Territories and finally passes southward through Texas on or near the 100th meridian.

In addition to this work of accurately defining the territorial distribution of the infection nothing has been done to add materially to the permanently valuable knowledge concerning this malady. Although attempts have been made to discover the cause they were not successful, as we shall be able to show. In 1889 the first systematic experiments were made by the Bureau of Animal Industry and these were at once fruitful in the discovery by one of us of a peculiar micro-organism in the red blood corpuscles which corresponds in every respect with what we should expect as the true cause. At the same time the other showed by field experiments that the cattle tick was somehow necessary to the transmission of the disease. These observations were fully confirmed in 1890. In the fall of the same year it was observed that when young ticks hatched artificially are placed on cattle there is a sudden extensive loss of red blood corpuscles accompanied by fever which could in no way be explained by the simple abstraction of blood. This discovery, at once followed up by additional experiments, brought to light the remarkable fact that Texas fever is caused by putting recently

*These numbers refer to the publications on this subject, p. 14.

hatched cattle ticks on susceptible cattle. All these results were reconfirmed in the summers of 1891 and 1892.

These investigations have thus far brought to light two important facts: (1) The constant presence of a blood corpuscle-destroying microorganism in Texas fever, and (2) the transmission of the disease from cattle to cattle by the cattle tick. The various experiments and observations which have led to these results are embodied in the following report and appendix.

The subject of Texas cattle fever has been treated of in the following publications, which are referred to in the text by the number prefixed to each title:

(1) Transactions of the New York State Agricultural Society, 1867, part 2.

(2) Report of the Commissioner of Agriculture on the Diseases of Cattle in the United States. Washington, 1871. (Reports by Mr. John Gamgee, J. R. Dodge, and Drs. J. S. Billings and Curtis.)

(3) Contagious Diseases of Animals. Special report No. 22. (Report by Dr. D. E. Salmon, pp. 98–142.)

(4) Report of the Commissioner of Agriculture for 1881–'82. (Report by Dr. D. E. Salmon, pp. 300–306.)

(5) Contagious Diseases of Animals. Washington, 1883. (Report by Dr. D. E. Salmon, pp. 13–44. Report by Dr. J. H. Detmers, pp. 103–145.)

(6) First Annual Report of the Bureau of Animal Industry, 1884. (Report by Dr. D. E. Salmon, Chief of the Bureau, pp. 214–221.)

(7) Second Annual Report of the Bureau of Animal Industry, 1885. (Report by Dr. D. E. Salmon, Chief of the Bureau, pp. 247–274.)

(8) Bulletin of the Agricultural Experiment Station of Nebraska, II, No. 3. (Southern Cattle Plague and Yellow Fever from the Etiological and Prophylactic Standpoints. By Frank S. Billings.)

(9) Texas Fever. By Paul Paquin. (Missouri Agricultural College Experiment Station, Bulletin No. 11, May, 1890.)

(10) Third Annual Report of the Arkansas Experiment Station, 1890. (Report by R. R. Dinwiddie, Veterinarian, pp. 98–122.)

THE NATURE OF TEXAS CATTLE FEVER.

PERIOD OF INCUBATION.

This term has no very definite significance in this disease, for it is used to designate different things. Thus it has been employed to indicate the period elapsing between the exposure of susceptible cattle to Southern cattle, or upon fields infected by them and the appearance of the disease. If taken in this sense it may vary from ten to ninety days. The great variation here observed is readily explained by the life-history of the cattle-tick, with which this period is intimately associated. A discussion is therefore postponed until the life-history of this parasite has been described (p. 114), and we content ourselves here by simply mentioning the facts as observed.

This term may also be used to signify the time elapsing between the introduction of the infectious agent into the tissues and fluids of the body and the first appearance of disease. This period is ascertainable by inoculation. In the case of subcutaneous and intravenous injection of blood from cattle suffering with Texas fever, the fever temperature appeared within a few days of the inoculation and outward signs of illness were manifest on or even before the sixth day. It is probable, therefore, that multiplication begins at once after the micro-parasite has been introduced into the body, and when it has attained a sufficient momentum the external symptoms of disease appear. This may be in from six to ten days, depending on the number of micro-parasites originally introduced, the predisposition and age of the animals, and the season of the year.

SYMPTOMS.

ACUTE TYPE.

In our experiments two types of disease have manifested themselves, the acute fatal type and a mild, rather prolonged, usually nonfatal type. As they differ in many respects, they will be considered separately.

The acute disease is the disease of the hot summer months. It appears suddenly and as a rule at the same time in all animals of a herd

which have been exposed to the same infection together. The fever usually precedes the outward symptoms by several days, and animals apparently quite well will show a high rectal temperature ranging from 105° to 108° F. The value of the clinical thermometer in thus detecting disease was pointed out by Gamgee and by the Metropolitan Board of Health in 1868. The latter have recorded a temperature of 109° F. (1, p. 1098.) A temperature above 108° F. has not been noted in our experiments. A glance at the tables in the appendix will show that the normal morning temperature of the cattle in our experiments ranges from 100.5° F. to 102.5° F., being in general somewhat lower in autumn than in midsummer. The temperature of calves and young animals may rise to 103° F. without being accompanied by any signs of disease.*

If the temperature of exposed animals be taken once daily, say in the morning, it will be found that at the onset of the disease it will rise within twenty-four hours from the normal to 104° F. or even higher. In the following twenty-four hours it may rise to 105° or 107° F. The continued daily record will then show a high temperature until the disease terminates fatally or in recovery. In the former case it may fall from 2° to 4° below the normal just before death. When recovery ensues it falls as quickly to or even below the normal as it rose in the beginning of the attack. If the temperature be taken twice daily, in the morning and the evening, a new set of phenomena appear. The temperature at the outset rises during the day, is highest in the evening, and may be low again in the morning. This oscillation, partly a normal occurrence, may be noticed for three or four days in some cases, the morning temperature gradually rising until it is as high as the evening temperature. The high temperature then remains continuous until the end of the fever. These facts are well exemplified in the following diagram:

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*These figures agree fairly well with those of other observers. "The temperature of healthy cattle ranges from 37.6° to 39.6° C. (99.7° to 103.3° F.). In some cases it may be even a trifle higher or lower. In the morning it is usually, but not invariably, 0.2° to 0.4° C. (0.4° to 0.7° F.) lower than at night. In calves and heifers it is usually somewhat higher than in old cows. * * * The general average from the results obtained by numerous observers is 38.8° C. (101.8° F.)."—Dieckerhoff (*Lehrbuch d. spec. Pathologie und Therapie f. Thierärzte, II.*) During very hot weather the evening temperature of cattle more or less exposed to the sun in the pastures of the station has been found to rise to 104° and even 105° F., although the animals were, so far as could be determined, in good health.

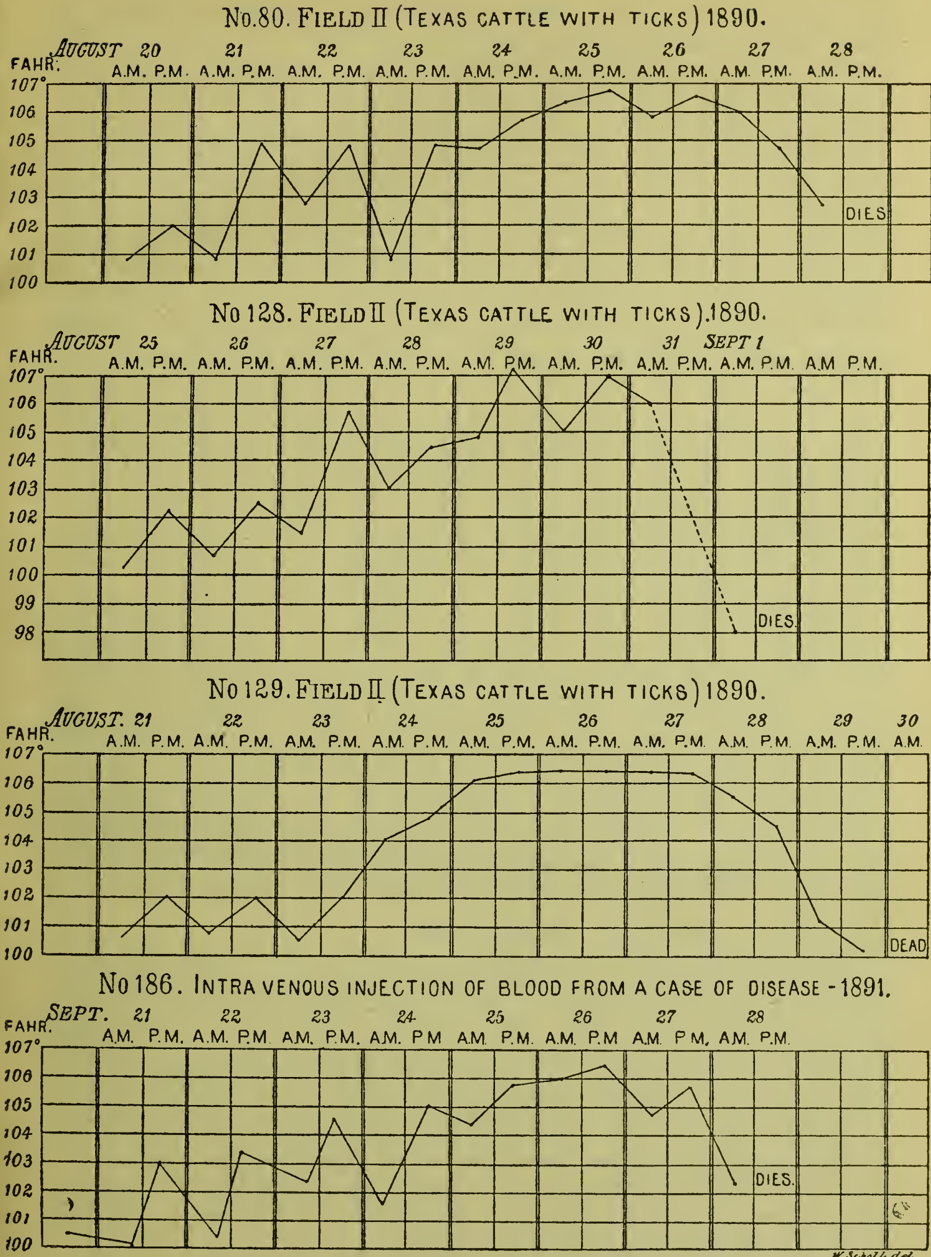

FIG. 1.—Temperature curves in four cases of Texas fever.

The fever may be detected by an experienced hand without a thermometer. The whole surface of the body feels hot to the touch. The heat is especially noticeable when the hand comes in contact with the anus or vulva in taking the rectal temperature. It is possible to go

over a herd of cattle and select those having a high temperature by simply placing the hand on the anus.

The pulse and respiration rise with the fever. There is considerable variation in the number of the pulse-beats and of the respirations during health, and there is also in some cases the excitement incident to being caught, which prevent our giving any very accurate figures. In health the number of respirations of the cattle used in our experiments may be put down as between 20 and 40 per minute, according to the temperature of the air and the age of the animal, while the pulse seems to range between 60 and 80 beats per minute.* In animals in the acute stage of Texas fever the respiration may rise to between 60 and 100 and the pulse to between 90 and 110. As the fever subsides and recovery begins the great weakness of the animal still keeps the pulse very high for a time, especially when the animal is moved about or excited in any way. The respirations, on the other hand, are apt to fall below the normal in this same period. When death approaches the heart-beats increase in number as they grow feebler, and the respirations fall with the body temperature below the normal. These statements are fully illustrated in the appendix by the individual cases.

Next to the high temperature the condition of the urine demands our attention. The one sign regarded as peculiar and pathognomonic in this disease is the discharge of urine having the color of blood. This color is not due to a discharge of blood from the kidneys and subsequent breaking up of the red corpuscles, but to a filtration of the coloring matter of broken-down red corpuscles (hæmoglobin) already in solution in the circulation into the urine in the excretory structures of the kidneys. This fact was first pointed out in 1868 by R. Cresson Stiles. In using the term hæmoglobinuria this is all that is meant in this report. The precise state or condition of this coloring matter in the urine does not call for consideration.

Hæmoglobinuria may be said to be present in most acute fatal cases of Texas fever. Out of 46 fatal cases in which urine was in the bladder after death, hæmoglobin was present in 33 cases.† A careful examination of the notes will show that in 13 negative cases‡ the animals were killed in the earliest stages of the fever, or else they died or were killed after the number of blood corpuscles had been greatly reduced

*The respiration in our cattle seems to have been higher than the normal of other observers. "Respiration in healthy cattle varies from 16 to 25 per minute, and may fall as low as 14 or rise as high as 30. According to the observations of Fürstenberg it is 21 per minute for cows and 24 for bulls."

The "pulse, like the respiration, varies greatly. According to Hering and Fürstenberg it is from 90 to 130 per minute during the first two weeks of life; from 70 to 80 from two weeks to two years. The average for a full-grown animal is 60, for old cows 50 to 55."—*Loc. cit.*

†Nos. 5, 6, 7, 8, 9, 11, 47, 50, 54, 66, 69, 74, 76, 90, 102_a, 103, 106, 108, 128, 129, 130, 139, 140, 144, 162, 163, 180, 186, 197, 198, 200, 203, 223.

‡Nos. 4, 10, 44, 48, 51, 71, 95, 134, 137, 169, 181, 184, 227.

and the acute stage of the disease was over. In the former cases the hæmoglobin had not yet been set free from the corpuscles; in the latter cases it had probably been eliminated one or more days before death. How frequently "red water" is passed before death we can not state with any degree of certainty, since its discharge may wholly escape observation. We have a record of hæmoglobinuria in but four cases: in No. 43 on the third day before death, in No. 44 on the fourth day before death, in No. 80 before it was killed (probably twelve to twenty-four hours before death), and in No. 198 twenty-four hours before death. In some of these cases it so happened that the urine was passed while the animal was undergoing examination. It is interesting to note in connection with the statements made that in No. 44 no "red water" was found in the bladder after death, although it had been passed four days previously.

Whether hæmoglobinuria is always present in acute cases of Texas fever it is impossible to state definitely. As it seems to depend upon the rapidity with which the red blood corpuscles are infected and destroyed, a slower destruction may allow other organs to take charge of the debris and thus forestall the discharge of hæmoglobin in the urine. In the notes will be found the record of hæmoglobinuria in but one acute case which recovered (No. 49), while in a number of cases in which the urine was collected, sometimes in the height of the fever, sometimes after it had departed, no hæmoglobinuria was detected.* In this solitary case the high temperature first appeared August 18. On August 23 the temperature being still above 105°, the urine was free from hæmoglobin, but contained a small quantity (.05 per cent) of albumen. On August 27 the temperature had become normal, but a second paroxysm followed soon after, and on September 4 and 5 the urine was of a port-wine color. Urine collected September 6 was again of normal color.

The urine during the fever, when free from hæmoglobin, contains in many instances a small quantity of albumen. The specific gravity may at first be high (1030–1040), and it may be strongly alkaline and effervesce with acids as in health, but, as the disease progresses and when the animal eats but little, its specific gravity will fall to 1010–1020; it fails to effervesce with acids and is faintly alkaline or even slightly acid. When the fever has subsided the urine has been observed to be in a few cases very watery, *i. e.*, of very low specific gravity and feeble in color. Within one or two weeks, however, the normal condition is restored.

The urine which contains the coloring matter of the blood varies, as might be expected, very much in depth of color, according to the concentration of the hæmoglobin. It may have a very light claret color, or it may be so deeply tinted as to appear opaque and blackish. In a

*Nos. 95, 105, 135, 137, 138, 182, 185, and many others in which the urine was observed to be of the normal color, but was not examined more closely.

test tube when viewed by transmitted light it may barely permit the light to pass unless diluted with water. (See Plate III, Fig. 4.) Such urine is, as a rule, entirely free from suspended matter and blood corpuscles. The latter may sometimes be found in small numbers when the urine is permitted to stand, and they may be derived from small hemorrhages in the pelvis of the kidney, quite regularly observed at autopsies. The coloring matter, as has been stated above, is derived from corpuscles broken up within the circulation, and not outside in the bladder. When such urine is treated with a little acetic acid a brownish flocculent precipitate, probably of the derivatives of hæmoglobin, appears. When boiled, a brownish flaky precipitate forms, which rises to the surface as a scum. As might be expected, such urine always reacts in presence of the usual tests for albumen. How much of the precipitate formed is the ordinary serum-albumen found in various forms of kidney disease and how much belongs to hæmoglobin does not come up for consideration here. Suffice it to say that in very opaque urines the precipitate is quite abundant and corresponds when Esbach's test is applied, to from one to three per cent of albumen.*

The subject of hæmoglobinuria is more fully discussed here under the symptoms because it is occasionally observed during life and probably with the aid of a catheter may be seen much more frequently. The causes of its occurrence and the way in which it is brought about will be discussed in connection with the microörganism. Very little need be said of the other characters of "red water." When found in the bladder after or collected shortly before death its specific gravity is usually low (1010–1020) and it is feebly alkaline or acid. There is no effervescence with acids. After standing a few granular casts and rarely urates are found in the very slight sediment. The greater the number of days before death that it is collected the more nearly it approaches normal urine as regards specific gravity and alkalinity.

The bowels are as a rule constipated during the high fever, and on post-mortem examination the large bowels (cæcum and colon) are found in some cases compactly filled with small, very firm, hard balls of dung. As the fever subsides the fæces again become softer and are then found more or less deeply tinged with bile.

Loss of appetite always, and cessation of rumination usually, accompany the high fever after the third or the fifth day. These, together with the enormous destruction of the red blood corpuscles and the temporary disorganization of some of the vital organs, lead to a rapid loss of blood during the fever and even to extreme emaciation during the period following the fever. Some observers have recorded the sudden and partial cessation of milk secretion. We have had no opportunity to observe this symptom.

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*If a few drops of acetic acid be added to urine holding much coloring matter in solution and allowed to stand over night, a clear yellowish liquid may be filtered off which gives the ordinary reactions for albumen.

Symptoms referable to disturbances of the brain and the spinal cord were rarely noted. They usually manifested themselves in partial loss of vision, delirium, staggering gait, and swaying of the hind quarters. These latter may in part be referred to the great weakness which cattle manifest after some days of fever and perhaps to the œdema around the kidneys. This weakness may become so great that they will be unable to rise even when urged. When standing there may be noted a trembling of the muscles especially of the hind quarters and limbs. Icterus or jaundice has not been noted in any case during life.

Another character of this disease, the most constant and valuable of all and of which the hæmoglobinuria or "red water" is but a part, is the thinness of the blood. A more thorough discussion of its condition will be given further on. In this connection we only mention those phenomena which can be witnessed by the naked eye. Soon after the high temperature sets in, the blood begins to grow thin and after some days of fever it has become very pale and watery. An incision into the skin readily shows this to be the case. The difference between the drop of rich red blood issuing from a slight cut of the skin in healthy cattle and the thin, pale drop oozing from such a cut in Texas fever is very marked. This difference is due to the loss of red corpuscles which give the blood its characteristic color. Associated with this there may be in some cases a marked bloodlessness of the skin in the later stages. A number of small incisions are often required to obtain a few drops of blood. In some cases shortly before death the blood slowly trickles from a slight incision for some time before it is checked by the natural process of coagulation.

When freshly-drawn blood is allowed to stand the serum forced out of the clot has in the acute stage a very dark-red color, indicating the presence of much coloring matter in solution. As regards the coagulability, which some observers have regarded as feeble, we have no facts pointing in one direction. In a few cases the coagulation appeared retarded; in others it appeared to be normal in rapidity and effectiveness. As will be seen further on, the condition of the blood must vary considerably from time to time. At one time it may contain the débris of destroyed corpuscles equal in number to one-tenth, or even one-fifth, of all circulating in the body. That under such circumstances its coagulability may be affected is evident. Frequently, however, the blood comes under observation when the destruction of red corpuscles has ceased and the products have either been excreted or metamorphosed. In this way conflicting observations may perhaps be harmonized. In general, we may say that the coagulability of the blood is not much altered.

We have thus briefly sketched the symptoms of an acute attack of Texas fever and noted three important diagnostic features, high temperature (or fever), hæmoglobinuria (or red water), and thinness of the

blood (or destruction of red corpuscles). The last is the most constant, and, in fact, the one essential character of Texas fever Among the other less important symptoms and appearances, many of which are always associated with one or the other of those mentioned, are dry, hot skin, high rate of pulse and respiration, loss of appetite, cessation of rumination and of milk secretion, constipation, hyperæmia followed by bloodlessness of the skin and mucous membranes.

The course and the duration of the disease are subject to variations. We have seen that it begins somewhat abruptly with a high temperature, runs its course in a few days, and terminates fatally, or else it disappears as quickly. In the latter case the disease is followed by a period of great debility, owing to the impoverished condition of the blood and the degenerative processes set up in the various vital organs, and not infrequently by relapses. Some animals never fully recover; in others recovery takes place after weeks and months.

The duration of the disease varies more or less, but the continuous high temperature rarely lasts longer than eight to ten days. The fatal termination may take place in the height of the fever—that is to say, four or five days after the appearance of a high morning temperature, and may be the direct result of the derangement of the vital functions, due to the rapid destruction of red corpuscles by the microörganism, or it may take place after the fever has subsided, when the animal fails to rally from the shock imparted to the system and from the drain of its blood-forming resources. If we take as our starting point of the fever the first high morning temperature death may ensue from four to fourteen days thereafter, or it may be delayed still longer, when the animal dies slowly of exhaustion. The period of disease for such as recover is practically the same. A fever period of eight to ten days is followed by a period of normal or subnormal temperature. The falling of the temperature marks the end of the destruction of red blood corpuscles and the disappearance of the parasite from the blood. The subject of relapses and secondary attacks during the season by which the period of disease as a whole may be prolonged into months is discussed on page 23.

The mortality from southern cattle fever varies greatly, as will be seen in the following pages on the mild chronic form of the disease. The time of the outbreak will largely decide whether practically all the attacked animals die or all survive. A midsummer outbreak, when acute in its nature, is the most fatal. From this there may be all gradations towards the mild nonfatal form of late autumn.

MILD, NONFATAL OR CHRONIC TYPE.

This type of southern cattle fever has hitherto remained unobserved. The reason for this is quite simple. It can be recognized only by an examination of the blood, which must determine the presence of the

micro-parasite in the red corpuscles and their approximate rate of destruction.

The mild form of Texas fever is largely a disease of autumn when the heat of summer has passed away. In the latitude of Washington, D. C., October and November, rarely the first week of December, are favorable to it. It is not, however, strictly limited to this period, as it may be observed from early August on through the entire season. Its occurrence during this latter period, which is commonly characterized by acute disease, is limited largely to the less susceptible calves and to a very few of the exposed adults. Cattle which have passed through the acute disease may have a relapse in the form of the mild type in autumn.

The essential difference between this and the acute type rests on the fact that a stage of the parasite circulates in the blood of the mild cases, which is different from the one observed in acute cases. This difference will be made clear in the chapter on the Texas fever parasite. When we come to the various symptoms there is only a difference of degree. The fever temperature is low and fluctuating, rarely rising above 105° F. in the evening. In the morning the temperature is usually normal or very slightly elevated. The destruction of red blood corpuscles by the micro-parasite goes on as in the acute form, but much more slowly and deliberately, and hence the period of disease itself—that is, the time during which the parasite is present in the blood in considerable numbers—is much prolonged. The hæmoglobinuria is probably never present. The various symptoms which accompany the fever are only present when the temperature is above 103° F. There is loss of appetite and dullness, especially when the number of red corpuscles has reached its lowest limit, followed by a slight falling away in the condition of the animal.

It will thus be seen that there are no symptoms manifest to the unaided eye which we might put down as characteristic of Texas fever in its mild type. It might be confused with a variety of disorders incident to the bovine species or else be entirely overlooked. From an economic point of view it is of not very great consequence, since it is not fatal, and the loss in weight, though quite considerable in some cases, is soon made up in the winter months.

THE RELATION BETWEEN THE ACUTE AND THE MILD TYPE OF TEXAS FEVER—RELAPSES.

In certain cases it was noticed that after the animal had recovered from the acute attack and the number of blood corpuscles had nearly reached the normal maintained before the attack it would again fall, and in the blood many corpuscles could be found containing the small stage of the Texas fever parasite which is always associated with the mild type. In other words, the acute attack would be followed after a

certain interval of time by a mild attack. This interval may vary considerably. Thus in No. 105 the acute attack began early in August, and the secondary, or mild attack, about one month later. In No. 160 the acute attack began early in September, the mild attack about three weeks later. In No. 49 the acute attack began near the middle of August, the mild attack was observed in the second week of October. Two cases of Texas fever (Nos. 206 and 219) induced by the intravenous injection of blood are particularly noteworthy in this respect. In No. 206 the disease began July 13, in No. 219 July 23. In both the mild attack was detected at the same time at the end of August, although it may have begun some days before.

The question naturally presented itself whether these secondary attacks are simply relapses or whether they are reinfections from without. As will be fully discussed further on, the young cattle-tick induces the disease in natives as soon as it has attached itself to their skin. Since the cattle-ticks are present on the infected field during the entire summer and autumn it is reasonable to suppose that the secondary or mild attacks may be caused by ticks which have remained on the field or by the second generation, since the usual time for mild attacks, late September and October, is the time for the appearance of a second generation of young ticks. Whether these mild attacks are always due to an invasion of the animal by such a second generation or whether they may be due in some cases to the recrudescence of the microörganism not yet entirely eliminated from the system was settled by the cases Nos. 206 and 219 above referred to. Since they were inoculated but once and there was no opportunity for reinfection these cases prove that a mild attack may follow an acute attack without a fresh importation of the microörganism from without; in other words, that the mild attack may be considered as a relapse. This conclusion does not operate against the probability that some mild attacks may be due to secondary infection from without.

In addition to the true relapses just referred to we may observe more or less oscillation in the course of the disease as expressed by the destruction of red corpuscles. This oscillation is probably dependent on the periodical multiplication of the micro-parasite and in this respect may be regarded essentially identical with the relapse. The latter follows the primary disease at long intervals, while the oscillations are but one and one-half to two weeks apart as a rule.* Neither the relapses nor the oscillations have been marked by any distinctive clinical signs excepting a slight rise of temperature in some instances. Such undoubtedly do exist and may perhaps be detected by more frequent daily measurements of the temperature and a closer and more frequent examination of the animals and their excretions than our time has permitted us to make.

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* See also p. 40.

PATHOLOGICAL CHANGES.

In dwelling upon the pathological changes caused by Texas fever we have had two objects in view; first, to add as much as possible to the information already on hand, and, secondly, to furnish such a complete record of the cases in the various experiments that there would be no room for doubt in the reader's mind that we were dealing with Texas fever wherever this is claimed to be so. Inasmuch as the causation or etiology was the essential object of the researches, everything else had to be subordinated to lines of investigations which endeavored to get at the causes and the modes of transmission of the malady before us. The following account, though somewhat meager for this reason, is given as a description of the nature of the disease we were dealing with. We may note here that the lesions induced by North Carolina cattle and those induced by Texas cattle at the same season were identical in every respect. (See Nos. 74, 80, 82, 107, 128, 129, 139.)

CHANGES IN THE ORGANS AND TISSUES.

Cattle which have succumbed to Texas fever undergo post-mortem changes very rapidly. This may be largely due to the fact that the disease occurs in the greatest heat of summer. Hence facts relating to the appearance of organs and tissues are of doubtful value if the animal has not been examined soon after death. This occurs as a rule during the night, and post-mortem changes are begun when the morning arrives. It is frequently desirable therefore to kill animals in different stages of the disease to obtain trustworthy facts.

The skin presents nothing abnormal to the unaided eye and, as will be pointed out later on, certain regions are beset with ticks. In one case (No. 197) which came to our notice very recently the hair on the abdomen and the inner aspect of the thighs was matted into little tufts by dried blood. The skin showed at such places a bluish elevated spot and when incised a little blood was found in the subcutis. This may be what has been called blood sweating.

The subcutaneous tissue and fat in our cases were free from any changes except in three (Nos. 7, 102_a, and 227), in which they were of a decidedly yellowish tinge. Jaundice was thus of rare occurrence. In the report of the Metropolitan Board it is stated that "the fat has a deep or high colored greenish appearance and has not the firm resistance of health. The lean meat is of a brownish mahogany color and on being cut into has a peculiar sickening odor." The muscular tissue in our cases was normal in color or perhaps a trifle paler. Œdema of the subcutaneous tissue of the ventral aspect of the body was occasionally present (No. 69) and referable to the debilitated condition of the animal.

The brain was removed in a small number of cases (Nos. 198, 200, 203, and 223) and carefully examined, but no lesions which can be re-

garded in any sense as peculiar to or characteristic of the disease were observed. It may be said, in general, that the brain shared the general tendency towards the injection of the capillary system. The vessels of the pia and the plexuses were engorged, and over the frontal lobes and near the great transverse fissure it was more or less pigmented—a condition also met with in other diseases. The gray matter of the cerebrum and especially of the cerebellum appeared of a more pinkish color. The white substance was normal in color, the ventricles free from fluid.

Lungs.—The lungs are, as a rule, healthy. There is, in many cases, pulmonary œdema, with or without emphysema, noticeable after death. In a few instances foci of dark red hepatization were observed in one of the principal lobes, which involved one or several lobules.

Heart.—At the autopsy the right ventricle is always distended with blood, fluid or clotted, according to the time elapsing between death and the examination. The left ventricle is usually firmly contracted, and may contain a small quantity of fluid or clotted blood. The clots are quite firm and very rarely mixed with firmer, pale yellowish clots. A very constant lesion is the extravasation of blood beneath the epi- and endocardium. This is mainly restricted to the left ventricle, although petechiæ are not infrequently met with on the right ventricle. On the external surface of the heart the petechiæ are usually grouped along the interventricular groove and near the base, although cases occur in which the whole ventricular surface is sprinkled over with them. The inner surface of the left ventricle shows larger patches of extravasation usually on, or at the base of, the papillary muscles. On the large vessels at the base of the heart, within the pericardial sac, there are frequently very delicate shreds of tissue or patches in a hyperæmic condition. The heart muscle, on closer inspection, is observed to have its minute vessels markedly injected, and in fresh sections the capillary network is found densely packed with red corpuscles. In cases which have succumbed after the subsidence of the fever the heart muscle is quite pale. Cloudy and fatty changes of the fibers are in some cases quite marked; in others absent or restricted to a small number of fibers.*

Lesions of the abdominal cavity are not infrequent. Œdematous conditions are quite common around the kidneys and will be referred to again. Gelatinous œdemas are sometimes encountered in the portal

*An interesting appearance, which may now and then deceive observers, is the presence, under the endocardium, of minute, whitish, fusiform bodies, perhaps one millimeter long, which seem to follow the course of the superficial veins and rest upon or near their walls. They are sarcosporidia (psorospermia) cysts filled with falciform bodies. These cysts are likewise present in the depths of the heart muscle and in the skeletal muscles. Under the endocardium their number is greatest in old cows. They are in some cases so numerous that fifty may be included in an area of a square centimeter. They are easily removed entire by careful teasing.

region between duodenum and liver. The omentum frequently displays peculiar hyperæmic patches consisting of delicate shreds of vascular tissue made visible to the naked eye by the injected condition of the blood-vessels.

Spleen.—That this organ in Texas fever is very much enlarged was commented upon by the earlier observers, and the name "splenic fever" took its origin from this condition. Gamgee, in 1868, caused to be weighed the spleens of a large number of native Western cattle, of Cherokee cattle (supposed to have come from the Indian Territory) and of Texan cattle. These animals were considered healthy and fit for human consumption.

The average weight of the native Western spleen was 1.45 pounds; of the Cherokee spleen, 1.94 pounds; of the Texan spleen, 2.5 pounds.

A number of spleens were weighed at one of the Washington abattoirs to determine the normal weight. The result is given in the following table:

Date.		Weight of steer.	Weight of spleen.
		Pounds.	*Pounds.*
October 10, 1890	No. 1	950	1.75
Do	No. 2	900	1.75
Do	No. 3	1,000	1.90
Do	No. 4	1,000	2.37
Do	No. 5	1,000	1.50
October 15, 1890	No. 6	1,300	2.25
Do	No. 7	1,100	1.75
October 22, 1890	No. 8	1,400	2.00
Do	No. 9	1,300	1.90

The source of these animals was not determinable. It will be noted that the weight varies considerably, although in all the appearance of the organ, both as to its capsule and pulp, was the same. The weight of each animal was estimated by the butcher in charge. These examinations were made at a time when any destructive influences of the summer on the blood may not have been entirely neutralized. How far the bleeding of the animals at the time of slaughter may have affected the weight of the spleen in comparison with that of cattle which succumbed to the fever with the blood in their system it is of course impossible to estimate. By taking the average of the above nine cases, the weight of the spleen of a steer weighing 1,000 pounds would be 1.72 pounds.

The weight of the spleen in Texas fever varies considerably, according to the stage of the disease in which the animal succumbs. Animals which die after some days of high fever have usually the largest spleens, although this is not an invariable rule. If we compare the weights of spleens as given in the appendix under many of the cases it will be seen that in acute cases the spleen is generally from two to four times its weight in health.

If we turn for a moment to examine its appearance we find its general shape unaltered, but the ordinarily rather thick whitish capsule very much distended and attenuated so that the dark pulp shows

through it very distinctly. (Plate I.) The veins of the capsule are distinct, the minute vessels markedly injected and occasionally accompanied by extravasations of blood. The organ is firm to the touch owing to its distended condition. When it is incised, the pulp appears as a dark brownish-red, glistening, homogeneous mass, which has been compared to "blackberry jam" in its appearance. The usual markings of the parenchyma of the normal spleen are effaced. The grayish Malpighian bodies and the whitish trabeculæ have all disappeared from view within the distended pulp. (The differences between the cut surface of the spleen in health and in Texas fever are well brought out on Plate I.) The pulp may be still firm, or it may be partly diffluent, welling out as a semi-fluid mass from the incised retracting capsule. It has occasionally been reported as ruptured, but this may be a combination of post-mortem softening with carelessness in its extraction. In some cases the spleen may be much heavier than in health, but its markings still visible on section.

A microscopic examination shows that the enlargement and peculiar color of the spleen tissue is due to an engorgement with red blood corpuscles. With this engorgement there may be associated a variable number of large cells containing coarse granules and from two to twelve red corpuscles, or else the remains of these corpuscles in the form of irregular clumps of yellowish pigment. The pigment is also free in masses of variable size. Examination of fresh pulp from spleens of healthy cattle showed that the presence of large quantities of free pigment of the form described is not uncommon.

Of all the organs *the liver* is the most seriously involved. (See Plates II and III.) The enlargement, congestion, bile-injection, and fatty degeneration were pointed out by R. C. Stiles, in 1868. Gamgee limited himself to matters of weight and evidently did not observe the extensive changes which the parenchyma underwent. In our own observations of healthy and diseased livers, the latter were probably from 3 to 5 pounds heavier than the former. The edges were well rounded off. The color of the surface was usually paler than in normal livers and in most cases of a peculiar mottled appearance. The mottling was due to minute irregular grayish-yellow patches usually 1 millimeter or less in diameter. When incised the parenchyma was remarkably bloodless in most cases, and a lac colored, thick blood poured from the cut ends of the larger hepatic veins. The color of the cut surface was either a uniformly brownish yellow or else mottled as on the surface. (Plate II, Fig. 1.) The mottling, on closer scrutiny with the naked eye or hand lens, was found to be due to a paler-yellowish discoloration of the zone bordering the intralobular veins. (Plate II, Fig. 2.) This zone of discoloration was the wider the more prolonged the disease, and in a few cases involved the entire lobule. Parallel to this degenerative process the consistency of the organ became less resistant, more doughy, and brittle.

In thin sections of fresh tissue* the most striking phenomenon was the filling up of the ultimate bile canaliculi so that the hepatic cells were inclosed in polygons of yellow lines forming a beautiful network. (Plate III, Figs. 1 and 2.) When the liver is teased and crushed the contents of these bile canaliculi may be found floating free in the form of rods, sometimes with Y-shaped ends. (Plate III, Fig. 3.) This stasis or filling up of the ultimate bile capillaries was present in nearly all animals examined. It was most pronounced in those whose death followed quickly after a high fever. In one case purposely killed in the early days of the fever the liver was the seat of marked congestion, the bile-stasis not having taken place yet. The extent of this stasis varies considerably. It may be seen in small isolated areas or else it may involve a large continuous territory. Owing to absence of connective tissue between the lobules it is quite impossible in fresh sections to make out accurately its distribution. It seems to be most frequently met with in the innermost or hepatic zone of the lobule (Plate III, Fig. 1; Plate II, Fig. 4), but it may also be found involving the entire lobule. Small bile ducts between the lobules are often found injected, and rarely lines of yellow injection may be visible to the unaided eye.

Associated with the occlusion of the biliary canaliculi and ducts is a more or less extensive fatty degeneration of the hepatic cells. This is most advanced in prolonged cases of disease. In several which came under our observation the fatty changes were so extensive that cells free from large quantities of fat could not be seen. Among other abnormal appearances may be mentioned the presence of irregular yellow clumps of pigment in the hepatic cells, and of stellate masses or blood-red needle-like crystals (Plate III, Fig. 2) of very minute size (hæmoglobin?). In one case (No. 139) large branched thrombi were found in some of the hepatic veins.

The pathological changes observed in sections and teased preparations of fresh liver tissue are more accurately interpreted in sections of tissue hardened in Müller's fluid and in alcohol. The material was imbedded in paraffin after having been passed through chloroform paraffin. Sections cut in this way were far more serviceable than those cut in alcohol. The injection of the bile canaliculi is seen only in Müller's fluid preparations or in alcoholic material cut directly without imbedding. The extent and location of the injection are variable. It may appear over an entire lobule or only a small portion of it. The fatty degeneration so regularly seen in fresh material shows itself in sections of hardened material in a peculiar vacuolated appearance of the cell protoplasm, the fat having been dissolved out. The vacuolation may be more pronounced near the center of the lobule, where the individual vacuoles may be as large as red corpuscles. Of these there may be

* These were usually made with a razor and examined in iodized serum. The freezing microtome was not generally used because it was desirable in this examination to preserve the red corpuscles.

several in a single cell, very little of the protoplasm remaining. The cell protoplasm of the peripheral zone of the lobule is uniformly vacuolated, the vacuoles being very small.

Another change that is of considerable importance in estimating the pathological effect of the disease is a tendency toward necrosis of the inner zone of the lobule. This process, which shows itself to the naked eye as a faint paler mottling of the liver tissue limited to the inner zone of the acini, seems to begin around the central vein and extend toward the periphery.* It is characterized by a degeneration and loss of the nuclei of the parenchyma cells. These changes are observable with various stains, such as hæmatoxylin, alum carmine, and the anilines (alkaline methylene blue, aniline water-methyl violet, etc.). Ehrlich's acid hæmatoxylin, with or without eosin, is a very satisfactory dye, owing to the intensity of the nuclear staining. The changes undergone by the nuclei are at first manifested by a feebler stain. The margin, which may be irregular, is stained, but the body of the nucleus is pale and usually contains several deeply stained round bodies simulating nucleoli. Later on these bodies are all that is left. They shrink together or even unite into a small irregular deeply stained mass. The cell protoplasm is much more feebly stained than in normal areas and its outlines are indistinct. This nuclear degeneration may appear in a compact area uniformly or we may find all grades of degeneration intermingled.† In tissue undergoing such changes the central portions of each lobule may appear much paler than the peripheral. The trabecular arrangement of the cells may be exaggerated by a widening of the lumen of the capillaries in the periphery and made indistinct or become obliterated in the central portions. The destructive changes in central regions may go on to a complete loss of the nuclei. This appears very well in methylene-blue stains. The necrotic portion refuses to stain at all and the result is a mottled section with the isolated unstained areas inclosed in an irregular network of stained material very striking even to the naked eye. Such mottling will, of course, appear with other stains, but not so distinctly. The extent of the necrosis may be as much as one-third or one-half of the entire volume of the lobule.‡

In endeavoring to account for the fatty and necrotic changes of the parenchyma we think it probable that the bile stasis, by plugging up with solid bile the ultimate bile canals, may interfere in some way with

* One may be at a loss to determine the limits of the lobules in the ox, owing to the absence of any complete connective tissue boundary. In stained sections they are readily made out by taking as a guide the connective tissue with its numerous stained nuclei in the spaces in which the interlobular vessels and ducts pass.

† J. H. Detmers (5, p. 137) observed in 1883 the disappearance of the nuclei and the reticulated appearance of the cell protoplasm. Babes, in 1889, described a similar condition in Roumanian cattle affected with infectious hæmoglobinuria. (*See* page 140.)

‡ See the appendix under Nos. 3, 6, 9, 47, 69, 74, 95, 106, 112, 139, and 198.

the nutrition of the parenchyma or exercise upon it some deleterious influence through the stagnating bile and thus set the degenerative processes in motion. The bile stasis is undoubtedly due to the breaking up in the capillaries of the liver of immense numbers of infected corpuscles. A large amount of débris is thus brought to the cells for transformation into bile. The result is an abnormal fluid containing a superabundance of solids (pigment) which is unable to flow in the bile channels. How far the degenerative process may be aided by any plugging of the capillaries with infected corpuscles it is impossible to state. In fact, the relation of the disintegration of the red corpuscles and of the bile stasis to the fatty degeneration and the necrosis around the central vein should be made the object of special pathological study.

Bile is found in the gall bladder in considerable quantity (one-half pint to a quart) after death. As might be anticipated from the description of the changes in the liver, this fluid is greatly altered. The usual limpid greenish fluid is replaced by an almost semi-solid mass. As it flows from the incised bladder it has been aptly compared to chewed grass. The presence of mucus makes it cohesive enough to be drawn out into long flat bands as it flows. When it is allowed to stand quietly in a cylindrical vessel a layer of flakes settles down which occupies not infrequently one-half of the entire column. The supernatant fluid is much darker than normal bile. The suspended matter appears to be made up chiefly of small yellowish flocculi or flakes. A deep yellow tinge is imparted to all vessels and to the hands coming in contact with it. When examined under the microscope, the suspended particles are resolved into amorphous yellowish masses mingled with bright golden points barely visible at 500 diameters. The common bile duct has always been found pervious and in many cases an abundance of bile is found in the small intestine.

The kidneys.—We have in a preceding chapter referred to the condition of the urine in this disease and have found it altered by the presence of certain abnormal products, hæmoglobin and albumin. We might therefore anticipate more or less alteration in the secreting organ, the kidneys. In a considerable number of cases a sero-sanguinolent condition of the connective tissue and fat about the kidneys is observed. In a few cases the ventral surface of the organs appeared like two large blood blotches. The portion of the abdominal wall upon which the dorsal surface of the kidneys rest is free from these effusions.

The kidneys themselves, like the other organs affected by this disease, vary more or less in color, according to the severity and stage of the disease. In those cases which succumb early in the fever and in which the bladder is filled with port-wine colored urine, the kidneys are enlarged and of a uniform dark brownish-red color throughout. The usual markings are pretty well effaced. When fresh sections are examined from different regions, the vascular system is found quite

uniformly engorged and distended with red corpuscles. The section is likewise sprinkled over with very minute pigment particles. Sometimes irregular masses of red corpuscles, run together as it were, are met with in the vessels of the pyramids. Lesions of the secreting structures are not discoverable. Hemorrhages are uncommon. In those cases which succumb after the hæmoglobinuria and the fever have passed away, the kidneys are paler than usual and the texture is quite flabby. Sections of the fresh tissue show in the cortex a considerable amount of pigment. In some cases the convoluted tubules are the elected seat of pigment deposit, and the epithelium of these tubes may be so filled with yellowish red pigment that they are easily traceable in their windings by their decided color. Fatty changes are occasionally met with in the epithelium, and the straight tubules of the pyramids may be filled with fat globules. Degenerative or necrotic changes of the epithelium were not noticed in sections of hardened tissue from a few cases stained in various ways. In those cases in which the capillaries were filled with red corpuscles, the latter were usually all infected with Texas fever parasites.

The pelvis and its ramifications were usually found beset with blood extravasations. It has already been remarked under the head of symptoms that in most cases the bladder is found containing from one to four quarts of urine holding more or less hæmoglobin in solution. Under the same head will be found a full discussion of this phenomenon so that it need not be touched upon here. The bladder itself may show a few ecchymoses on its inner surface.

Digestive organs.—The upper portion of the digestive tract, including the paunch and reticulum, is generally free from morbid changes. The third stomach or manyplies was, in a few cases, somewhat "impacted;" that is, the contents were firm and rather dry and the superficial layer of epithelium of the lining membrane tended to peel off. In most cases it was normal. The fourth or true stomach (abomasum) shows not infrequently a hyperæmic condition. In some cases the laminated portion was of a uniformly bluish-pink color. Both Gamgee and the Metropolitan Board of Health of New York City have laid much stress upon the lesions observed in this organ. Gamgee describes in addition to the general hyperæmia three kinds of lesions of the laminated, cardiac portion. He finds in some cases petechiæ, "resembling flea-bites" in some respects, whose "center is dark and sometimes softened and perforated." In others "the reddened folds are studded with minute yellowish-gray granulations due to a change in the epithelium, which becomes swollen and has a tendency to drop off. Each granulation does not usually exceed the size of a pin's head. This appearance is most marked where the folds are most congested and in some cases where the congestion is slight it requires a somewhat careful inspection to recognize the presence of this change." The third lesion is described as follows: "Scattered throughout the folds,

especially near their free edges, we find * * * marked erosions, as if the epithelium had been peeled off with a sharp finger-nail."

The lesion described as the second was also present in many of the cases recorded in the appendix. Its constant appearance was very puzzling and might readily lead one to suspect some relation to the disease. Many of the granulations had their center perforated so that they suggested the presence of enlarged glands with hyperplasia of the tissue surrounding the mouth. It was not until the fall of 1890 that the nature of these little elevations was solved. In an animal killed for some purpose, though free from the disease, marked lesions of the mucous membrane of the fourth stomach were found. These consisted of yellowish-white exudations about as large as split peas, viscid and composed of round cells mixed with mucus and associated with the mouth of these elevated spots. A careful microscopic examination of this exudate showed the presence of a very minute nematode, a strongyle, imbedded in the exudate. That this was the cause of these lesions was soon determined. Some sections of the fourth stomach of a case of Texas fever in which these lesions were present had been prepared sometime ago, but had not been studied, for want of time. These were now examined, and in the minute pits corresponding to the perforation in the center of these granulations the worm was seen coiled up at the base of the epithelial layer. It was also recognized as the worm found and described a few months before by Ostertag in cattle slaughtered in Berlin, Prussia. The worm described by him was larger, but the fact that it produced the same lesions made it highly probable that the two strongyli are of the same species.* This disposes of the second lesion seen by Gamgee. As regards the first, it is not unlikely that it represents the earliest stage of the invasion of the mucous membrane by the worm, but we will not be dogmatic on this point.

As regards the erosions, it may be said that in a small proportion of our animals, irregular, very shallow, flattish excavations of the mucous membrane were found which had a blackish base. They varied much in size, some being quite small. They were most numerous on the laminæ. Some were occasionally encountered in the pyloric portion. After finding these same erosions even quite abundantly in some healthy stomachs from an abattoir we interpreted them simply as traumatic erosions due to the accidental presence of some foreign body.

In the investigations of the Metropolitan Board in 1868, the pyloric portion of the fourth stomach was found in many cases to contain deep, ragged excavations with hemorrhagic base. It is not improbable that at least some of these may have been the result of vascular occlusion, since in the animals examined at that time there seems to have been so far as the descriptions and illustrations go, much more congestion

*Ostertag named the worm *Strongylus convolutus*, but this was changed by Dr. C. W. Stiles, of this Division, who gave some attention to the worm subsequently, to *Strongylus Ostertagi*. Journ. Comp. Med., 1892, p. 147.

of the fourth stomach and intestines than in our own cases. These erosions were extensive in but one case (No. 198) of ours. Their constancy led Moreau Morris in his report to the Board to consider them as a more certain indication of Texas fever than the other lesions commonly present. With this we can not agree. In fact we regard the digestive lesions as perhaps the least pathognomonic of the disease.

In a few cases affected with a more or less chronic after-disease, there was much œdema of the coats of the fourth stomach, extending also to the mesentery.

The lesions of the intestines are limited to hyperæmia and pigmentation. Beginning with the duodenum, there is found generally an abundance of bile and more or less injection and pigmentation of the villi appearing in the form of closely set points and fine lines. The remainder of the small intestine may show with the stomach more or less marked congestion, or there may be patches marked by the injection of minute vessels. In many of the cases examined the mucosa was pale and concealed by a thin layer of a grayish pasty consistency made up largely of desquamated epithelium. The walls of the lower half of the small intestine contained quite invariably small worm tubercles. These appeared from the serous surface as dark bluish, slightly elevated nodules. In passing the opened intestine between the fingers the mucosa was found intact while the tubercles gave one the sensation of small shot in the walls. They harbor a parasitic worm and have nothing to do with the disease.

In the large intestine we find more or less hyperæmia and pigmentation in longitudinal lines corresponding to the summits of the folds of the mucous membrane. This condition is more marked in the cæcum and rectum than in the colon and seems to be associated with the constipated condition. Thus the cæcum is in some cases distended with very hard, dry, fecal balls and some may be found in the rectum. In some cases no abnormal condition of the large bowel is discoverable.

Differences in the pathological changes of our cases and those studied by former observers.—We have already called attention to the fact that, while jaundice was rare in our cases, it has been rather common according to other investigators. In fact it has been named "the yellow fever of cattle" on the strength of this symptom. Attention has also been called to the lesions of the fourth stomach in this respect. The causes for these differences may perhaps be looked for in the different condition of the animals examined. The Metropolitan Board in 1868 examined cattle which had been traveling and had undergone much hardship both by rail and on foot. They were all western animals which succumbed soon after their arrival in New York. How far the deprivation of food and water, the crowding, the constant motion, and the marching may have contributed to a more active circulation and to an absorption of the obstructed bile from the liver into the blood must remain a conjecture. In our cases the animals were simply

pastured and the frequent blood examinations as well as the taking of the temperature were carried out with the least possible disturbance to the animals. Again the animals used by us weighed between 500 and 800 pounds. They were not more than average animals in an average condition of flesh. It may be that the large fat animals in a plethoric condition would develop the peculiar condition of the muscular system, the jaundice and the more marked hyperæmia (and sloughing?) of the fourth stomach and intestines observed in 1868. The essential lesions, however, are precisely the same. The disease first studied by Gamgee and the Metropolitan Board of Health in 1868 is the same as that now occupying our attention. The changes going on in the blood, the liver, spleen, and kidneys are so striking and peculiar that they could not very well belong to two different maladies.

CHANGES IN THE CORPUSCULAR ELEMENTS OF THE BLOOD.

The condition of the blood, so far as determinable by the naked eye, has already been referred to. It grows very thin and watery as the disease progresses. This fact was emphasized by the earliest students of this disease, the investigators of the Metropolitan Board in 1868. Its prime significance seems to have escaped them and subsequent ones. In the preliminary pathological examination of four cases in 1888 (Nos. 3 to 6 inclusive) the destruction of red corpuscles explained best of all the conditions observed. Hence the importance of concentrating the attention on the blood and its cellular elements was at once recognized. In 1889 arrangements were made by which cases of the disease could be studied during life at the experiment station, and within easy reach of the laboratory, in the District of Columbia. In order to measure in some accurate manner the changes going on in the blood, the red corpuscles were counted as soon as living cases were accessible. The result proved surprising in the extreme. It was found that there is a destruction of red corpuscles going on from day to day quite enormous in acute cases. Going parallel with this diminution in the number of corpuscles a change in their size and appearance became manifest which demanded a careful study in order that a distinction between the stages of the intraglobular parasite and the altered corpuscles which might be confounded with them could be made. As the investigations proceeded an accurate knowledge of these changes proved very valuable as a means of diagnosis. In a number of cases the recent existence of Texas fever could be at once determined by their presence, even though the Texas fever parasite was no longer to be detected in the blood. These changes must now be considered as next in importance to the parasite itself in the diagnosis of Texas fever in all its forms. The present chapter is therefore a consideration of the changes, both quantitative and qualitative, affecting the red corpuscles without reference to the micro-parasite accompanying them. This will be described in another chapter.

THE DESTRUCTION OF RED BLOOD CORPUSCLES.

The red corpuscles were counted with the apparatus of Thoma, constructed by Zeiss. In the direction for use accompanying the apparatus it is suggested that 200 spaces should be counted in order to reduce the errors to a minimum. Owing to the large quantity of work that had to be done in connection with the various field experiments to be described, the counting could not be carried to the point of accuracy indicated. Moreover, the quantitative changes in this disease are so gross that a slight error will not affect the comparative results. The method adopted was to count 40 spaces. Two parallel rows of squares through the ruled field were counted. Such rows were chosen through which an additional line was drawn in order to guide easily the eyes. Hence these rows were always four squares apart. By counting the red corpuscles in a row of squares any differences in their distribution from one side of the cell to the other were thus averaged. A comparison of the results of counts in the case of healthy controls, or of animals before the onset of the disease, shows a remarkable uniformity of results. Moreover, successive counts either from the same dilution or from separate dilutions of blood from the same animal collected at the same time, showed that the greatest margin of error was one to two hundred thousand, a comparatively insignificant figure in the work before us.

It was necessary also to make a modification in the collection of blood. The uneasiness of many animals, the presence of flies, the heat and wind on the fields made it necessary to act with great rapidity. Hence the complete filling of the capillary tube was dispensed with. Only a fraction of the length was filled with blood, usually from 0.6 to 0.9. The quantity aspirated was at once noted and the 3 per cent salt solution or Toison's fluid was drawn up to the mark indicated. In those cases in which the blood was very thin and the various squares contained only from 0 to 3 corpuscles about 80 squares were counted.

If, in the collection of the blood, the dilution with the salt solution or Toison's fluid, its proper mixing with the blood, and especially the placing of the drop in the cell, be properly carried out the necessity for counting a large number of squares is made nugatory. Special care should be devoted to the cleaning of the glass cell and cover and the keeping away of all dust. When the coverslip has once been laid on the cell it should not be slid or moved about, so that the uniformity of distribution is not disturbed. The process of collecting the blood for counting is as follows:

In most cases the animals could not be removed from the field and the examination of the blood had to be proceeded with on the field itself. The various appliances necessary for the securing of fresh and dried preparations of blood and the counting of the blood corpuscles, were carried in boxes or trays. The animal was secured by its head and, in rare cases, one hind foot was tied, to forestall any injury to the

one collecting the blood, whose entire attention had to be given to this work. If desired, a rectangular box or stall may be placed in each field into which the animal may be led and secured. Or such a box may be placed under cover and then rainy weather will not interfere with the work.*

In collecting the blood the hair is clipped and shaved away over an area 2 or 3 inches square on that region of the rump overlying the flaring hip bones (ilium), where the animal is most accessible for this work. The shaven skin is washed and rinsed with clear water and dried with absorbent cotton. To make the incision a spring lancet is used resembling those advertised and figured in most catalogues of medical and veterinary instrument makers. The incision must pass through the depth of the skin in order that a sufficient flow of blood be secured. The depth to which the blade of the lancet penetrates may be regulated by a screw in the forked guard attached to the lancet. The lancet should be flamed in passing from one animal to another. The soap and razor should not be used on sick and healthy alike, for, although we have no positive evidence that the disease may be transmitted, either by these things or even by the lancet, such transmission is within the range of possibility.†

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*Such a box is best constructed as follows: Place three pieces of 2 by 4 studding, 4½ feet long, on the floor parallel to each other and 3 feet apart. Erect uprights also of 2 by 4 studding, and 3 feet high, 15 inches from the ends of each horizontal piece, and brace securely from the outside. Within this framework build, by boarding up on the inside, a rectangular box 6 feet long, 3 feet high, and 2 feet wide, open at the top and one end. The front closed end of the box is hollowed out to a depth of 7 to 8 inches to receive the neck of the animal in the standing position, so that the head may extend over the end and be secured to a framework extending 1½ feet beyond the box and attached to the box 2 feet from the floor.

The whole framework must be very securely put together. The projection of the studding at the base with the braces on the outside serves to strengthen the box and to prevent its upsetting by the struggling of the animal. A bar can be slipped in behind the animal to keep it from backing out, and a rope or strap over the withers fastened to the sides of the box will prevent the animal rearing forward.

† We give a specimen page of the figures obtained from counting the blood corpuscles as described above.

No. 218 (*healthy control.*)—August 6, 1892, 10 a. m.: Temperature, 101.8; repiration, 64; pulse, 56; blood collected, 7.3 divisions.

(Toison's fluid was used in this estimation. It consists of distilled water 160 cc., neutral glycerine 30 cc. (at 30°), sodium sulphate 8 grams, sodium chloride 1 gram, methyl violet .025 gram. It stains the white corpuscles so that both red and white may be counted in the same preparation.)

First row of squares:

8	12	9	13
13	11	10	14
12	13	13	10
14	19	8	13
12	7	10	10

61+62+50+60=233

$$\frac{463 \times 100 \times 4000 \times 10}{40 \times 7.3} = 6,342,465 \text{ red corpuscles.}$$

The number of red corpuscles in cattle (obtained from the counties around the District of Columbia) during health fluctuates more or less, as might be expected, but may be put down as six millions in a cubic millimeter. Seven millions in winter, and five millions in late summer and early autumn seems to be not uncommon. The number may be said to fluctuate, however, between four and one-half and eight millions, since these extremes are occasionally met with. The following counts from healthy animals will serve as illustrations:

No. 109.

September 18, 1890	5,726,000
October 3, 1890	6,190,000
October 14, 1890	5,807,000

No. 91.

October 1, 1890	4,672,000	Placed in infected field.
October 7, 1890	4,833,000	
October 30, 1890	4,670,000	

No. 143 (control animal).

September 29, 1890	6,261,900
October 8, 1890	6,835,000
October 25, 1890	6,500,000

In addition to these illustrations there may be found in the appendix a large number of figures relating to the number of red blood corpuscles of cattle in infected fields, but not yet diseased. The examination of the blood in 1891 was extended to many, and in 1892 to all, animals at the beginning of experiments, in order to get at the approximate normal for each animal, and also to make sure that the animals were in good health. Among the many cases which came under observation only one anæmic cow was found; that is, only one whose red corpuscles fell below four and a half millions. This animal (No. 136) was affected with some catarrhal discharge from the vagina. Her record was:

September 30, 1890	3,911,300
October 8, 1890	3,753,800
October 18, 1890	3,735,300

Second row:

8	14	7	13
11	9	10	8
15	13	13	13
8	8	15	17
12	13	9	14

$$54+57+54+65=230$$

$$463$$

Seven white corpuscles in 400 squares.

$$\frac{7 \times 100 \times 4000 \times 10}{400 \times 7.3} = 9{,}589 \text{ white corpuscles.}$$

In counting 40 squares the various factors in the fraction above balance each other in such a manner that it is only necessary to divide the number of corpuscles (463) by the quantity of blood collected (7.3 divisions of melangeur instead of 10, the quantity usually collected). The first figure of the quotient gives millions. A similar simplification of the formula for the white corpuscles may be used.

In one case (No. 51) tuberculosis, limited chiefly to the lymphatics, was discovered at the autopsy. Even in this animal, after three days of high temperature from Texas fever, the corpuscles still numbered 5,125,000. There could have been no anæmia, therefore, in spite of the tuberculosis.

The destruction of red corpuscles is the essential phenomenon of Texas fever from which all the various pathological processes take their origin. A glance at the figures in the appendix will show that this is a constant occurrence and present in every case in proportion to the acuteness and severity of the attack. Some illustrations will demonstrate these statements.

No. 80.

[July 5, 1890.—Beginning of exposure in infected field (Texas cattle).]

Date.	Number of corpuscles.	Remarks.
July 31	6, 290, 000	
August 4	5, 052, 000	
August 7	5, 631, 000	
August 23	5, 422, 000	
August 24	5, 434, 000	First high morning temperature on Aug. 24.
August 28—1 p. m	2, 025, 000	To all appearances in dying condition; killed.

No. 129.

[July 5, 1890.—Beginning of exposure in infected field (Texas cattle.)]

August 11	6, 123, 000	
August 13	7, 171, 000	
August 16	5, 370, 000	
August 27	3, 210, 000	First high morning temperature Aug. 24.
August 29	1, 675, 000	Died at 8 p. m.

No. 163.

[July 2, 1891.—Beginning of exposure in infected field (North Carolina cattle).]

August 13	5, 000, 000	
August 24	3, 388, 800	Temperature last taken on 21st, then normal.
August 25	2, 645, 000	Killed.

These few examples will suffice to illustrate the rapid disappearance of red corpuscles from the circulating blood. They are by no means extreme cases, but stand for the average rate of disappearance in acute cases. This would be for No. 80 at the rate of about 1,000,000 corpuscles per cubic millimeter a day during the last three days; for No. 129 at the rate of 800,000, and for No. 163, 700,000. That this rate of destruction is very high becomes evident when we bear in mind that in No. 80 it represents the loss in twenty-four hours of one-sixth of all the red corpuscles usually circulating in the body. In the other cases it represents from one-seventh to one-eighth of the whole number.

In the mild non-fatal type the rate of destruction is lower.

No. 56.

[September 8, 1890.—Beginning of exposure in infected field (North Carolina cattle).]

Date.	Number of corpuscles.	Remarks.
1890.		
September 20	6,844,000	
September 22	5,640,000	
September 29	5,307,000	
October 9	5,436,000	
October 22	4,666,000	
October 25	2,754,000	
October 30	2,720,000	
November 6	2,344,000	
November 8	1,984,000	
November 13	1,183,000	Lowest point reached.

In this animal, the loss which in an acute case would have taken place in four or five days occupied from seven to eight weeks. In these cases, however, other elements enter, such as the constant active production of new corpuscles which masks to a great degree the actual rate of disappearance. Moreover, the destruction seems to go on not regularly but in jumps or paroxysms. Thus in the case before us there was a decrease of 1,912,000 from October 22 to October 25, but practically a standstill from October 25 to October 30, and so on.

Another fact of considerable interest brought out by the periodic estimates of the red corpuscles is the oscillation of the number up and down during the disease in some cases. It seems as if a period of destruction were followed by a period of regeneration, and this again by a period of destruction. This oscillation is occasionally traceable to the reappearance of the micro-parasite in the blood, as in No. 160, in which three different downward movements in the number of red corpuscles are associated with the reappearance of infected corpuscles. In other cases the microscope did not, during the downward movement, demonstrate the presence of the parasite, probably because such observations were often one or two weeks apart. The supposition at the time was that such cases were getting well, and the tardy examination of the blood showed instead of the expected return to the normal another downward movement. Very good illustrations of this oscillation are afforded by Nos. 111 and 142, both the result of the intravenous injection of blood from sick natives. In No. 142 the figures were as follows:

September 16, 1890	6,890,000
September 22, 1890	5,430,000
September 24, 1890	4,562,000
September 29, 1890	5,274,500
October 4, 1890	3,902,000
October 8, 1890	*5,983,600
October 22, 1890	4,333,000
November 4, 1890	5,586,000

*This number is evidently too high as compared with the preceding, and must be explained by assuming other forces at work in concentrating the blood beside the mere regeneration.

It has been assumed above that the disappearance of the red corpuscles is chiefly due to their destruction. We have already seen that in the cases under observation there were very few hemorrhagic lesions which might for the time being reduce the number. The ticks can not be regarded at all as abstractors of blood in this stage.* That they are largely destroyed within the body is shown (1) by the loss of hæmoglobin through the kidneys, (2) by the overproduction of bile which is abnormal in the abundance of pigment flakes, and (3) by the actual observation of this destruction by the micro-parasite under the microscope.

THE REGENERATION OF RED BLOOD CORPUSCLES.

As determined by actual enumeration.—Passing by, for the present, any further discussion of this interesting subject, let us turn to the regeneration of the red corpuscles. This, of course, varies in accordance with the vigor of the animal, its food, and the season of the year. It is, even under adverse circumstances, remarkably rapid and well adapted to occasion surprise.

The regeneration of corpuscles as indicated by the microscope is not in all cases indicated by the counting apparatus. That is to say, the regeneration may begin before the destruction has ceased, and if the latter process is the more active the count will show a loss, although the microscope may demonstrate the presence of a large number of new corpuscles. This actual regeneration, as indicated by abnormal forms, will be discussed farther on; here we will simply refer to the increase of the corpuscles as indicated by actual counting. A few illustrations will serve our purpose:

No. 64.	
September 9, 1890	3, 154, 000
September 16, 1890	4, 575, 000
September 29, 1890	4, 869, 000

No. 102.	
September 18, 1890	1, 950, 000
October 4, 1890	2, 682, 700
October 17, 1890	3, 894, 700
November 6, 1890	5, 120, 000

No. 65.	
November 4, 1889	1, 720, 000
December 2, 1889	3, 463, 000

No. 56 (*Mild type.*)	
November 13, 1890	1,183,000
November 15, 1890	1,534,000
November 17, 1890	1,655,000
November 21, 1890	2,615,000
November 26, 1890	3,880,000
December 2, 1890	4,706,000
December 11, 1890	4,603,400

* The enlarged spleen, it is true, absorbs from 1½ to 3 pounds of red corpuscles roughly speaking, since its enlargement is mainly due to an engorgement with them. If we regard the red corpuscles as constituting one-third of the weight of the blood, this quantity would correspond to 4½ to 9 pounds of blood. If we take the blood in cattle as one-thirteenth of the body weight (v. Limbeck, Klinische Pathologie des Blutes. S. 49) an animal weighing 800 pounds would carry 61.5 pounds of blood. The spleen would thus absorb the corpuscles of one-fifteenth to one-seventh of the entire blood and reduce the number of corpuscles in a cmm. one-third to one million. The capillary engorgement of the kidney, heart muscle, and perhaps other organs may account for some losses, but this is mainly due to infected corpuscles which may be regarded as destroyed. The above calculation is, of course, very approximate.

The activity of the regeneration is well brought out in No. 56, a large, vigorous ox. From November 17 to November 26 the red corpuscles appeared in the circulation at the rate of 250,000 per cubic millimeter per day. From November 26 to December 2 the rate of increase was about 140,000 a day. It is furthermore remarkable that in the case of a few calves under observation the corpuscles rose rapidly in number, although the animals did not thrive after the fever departed. This was likewise observed in some adults. The blood-forming function seems to go on independently of downward processes of other functions.

No. 82.

October 11, 1890	3,542,800
November 13, 1890	4,240,000
December 2, 1890	5,643,000

In this calf, the number of corpuscles steadily rose after the disease had passed away, in spite of growing weakness and diarrhea. On December 4 it was unable to get on its feet, so that it had to be killed December 6. Opposed to these cases in which the blood-forming function asserts itself under difficulties, there are others in which the strain upon this function has been so severe that several phenomena appear. The corpuscles may increase in number but not reach the full tide of the number present before disease until the following season. Or there may be a temporary standstill in the production of corpuscles when the number is still very low. In none of the cases in which the convalescence was followed with the corpuscle counter did the number remain below four millions after the end of three or four months,

As determined by microscopical examination.—The reproduction of new corpuscles as witnessed by microscopical examination presents a number of important phenomena. Taking it for granted for the present that we are able to detect newly formed corpuscles by certain peculiarities of form and staining which they possess during the more advanced stages of anæmia, we may lay down a few general propositions concerning this production. In the acute type of Texas fever, when the daily loss of corpuscles amounts to from one-sixth to one-eighth of the normal number, there is observed little or no production of new corpuscles, until the number has fallen to one million or two millions, and the normal temperature has returned. Then an abundant crop of new forms is seen, even when the animal succumbs in the end. In the mild, non-fatal type, in which the destruction of red corpuscles goes on much more slowly, and in intervals, and in which there is but little fever and general disturbance of health, the production of new corpuscles begins at once and continues parallel with the destruction of older ones throughout the course of the disease. It is in such slowly progressive cases that the changes in the corpuscles accompanying their regeneration is best studied. Before proceeding to a description of these forms, so valuable in the diagnosis of Texas fever, a brief description of the methods employed is called for, since they are the

same as those used in the important study of the micro-organism or blood-parasite of this disease.

The blood was examined in the fresh and in the dried condition. The drop of blood as it oozed from the incision was received at once on a flamed platinum loop soldered into a glass rod like the ordinary bacteriological loops used for inoculating, etc. The platinum loop is simply brought in contact with the blood, and the drop placed on a clean glass slide and immediately covered with a cover glass and sealed with paraffin if the preparation is to be kept under observation for some time. The sealing is best done with a camel's hair brush dipped into melted paraffin. It is always desirable to have only a single layer of corpuscles in the preparation. To insure this there should be no speck of dust on slide or cover, and the quantity of blood taken must be small. This can be regulated by adjusting the size of the platinum loop. In the usual method of touching the drop of blood with the cover directly the quantity of blood can not be limited, and many preparations are subsequently found to contain too many corpuscles.

The preparation of dried blood requires much care. Without going into an extended discussion of the relative merits of different methods we give the one found most satisfactory and adopted in these investigations. It is most readily understood by referring to the annexed figure:

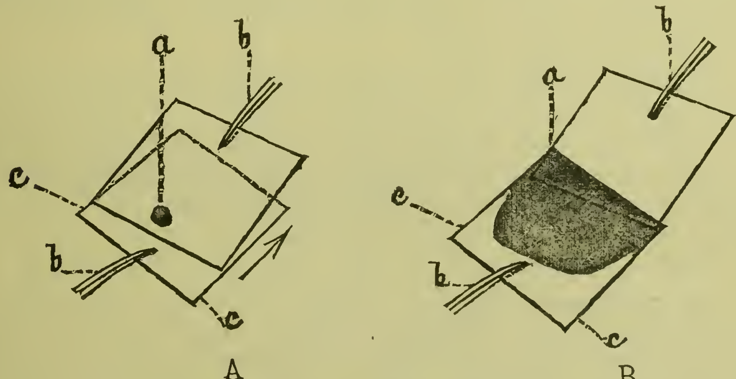

FIG. 2.—Method of preparing dry blood films on cover glasses.

In A, a cover glass *cc* is held by a pair of forceps *b* and has on its upper surface a drop of blood *a* placed there by a platinum loop. A second cover glass or "scraper" held by forceps is resting on the first with one edge and is held at an angle of 15° to 20° to it. As shown in B the upper cover is drawn over the lower, and as its edge sweeps over it it spreads out the drop of blood in a thin layer. In rapid work the forceps may be dispensed with. The lower cover is held between thumb and forefinger of the left hand at *cc* and steadied below with the tip of the middle finger, and the upper is firmly seized between thumb and forefinger of the right where the blades of the forceps would rest.

By using a pair of forceps which may be adjusted by a clamp, the scraper may be fastened between the blades, and by rotating it its edges may serve to spread out three or four separate preparations. The scraper should be thick and its edges smooth in order to insure uniform distribution of the blood. It is needless to say that this simple process is much superior to the barbarous one of placing two cover glasses together face to face in order to allow the blood to spread in a film between them, and then drawing them apart. Each corpuscle is thereby subjected to a long crushing process, whereas in the method before us this is entirely avoided. The thinness of the blood film depends upon several things, such as the condition of the cover as regards freedom from all grease, the size of the drop of blood, the regularity of the edge of the second cover or "scraper," and the angle at which it is held during the operation. The layer is not of even thickness over the entire cover glass, but is thinnest where the scraper has begun its work, and densest where it has left off at the edge of the cover, as shown in the figure. This is no disadvantage, however, but rather an advantage, as it furnishes us with a layer of varying thickness which is of service, as will be pointed out farther on. The place where the scraper began and where the layer is composed of isolated corpuscles or groups of contiguous ones, they have dried so rapidly that they are in a state of perfect preservation. Every preparation has thus some spots where the corpuscles are thoroughly "fixed," even if as a whole it may have been a failure.

The essential condition of success in dry preparations of blood is to get the corpuscles into a dried state as soon as possible after the blood is shed. For this reason it might seem desirable to eliminate the use of the loop and touch the exuding blood directly with the cover glass, as is frequently done in the study of human blood when the finger tip is pricked. But the circumstances are different in cattle. The prick is useless and an incision must be made. The surface of the skin is flat and a cover glass touched to the oozing blood may bring with it epithelial scales and other objectionable things from the skin accidentally touched, however much the latter may have been cleansed beforehand. Still, in rapid work, it is now and then of advantage to touch the oozing blood directly with the edge of the scraper. Not infrequently the quantity of blood is small and does not well out of the incision. A loop then becomes indispensable in lifting it out.*

The dried films of blood, kept labeled in small pill boxes until used, are exposed in a dry-air oven to a temperature of 110°–120° C. for one and one-half to two hours. Drawing the covers through the Bunsen flame as for bacteriological preparations is liable to fail at any time from overheating or underheating, and is not to be recommended.

* More recent observations during the fall of 1892 have shown quite conclusively that cold rapidly destroys the form of red corpuscles. In fact it was impossible to prepare films out of doors in a temperature below 50° F.

When, for rapid work, this method must be used the cover glass should be drawn through the flame four times, each movement to occupy a second. Three movements are usually insufficient, for when the stain is applied the coloring matter of the corpuscles is dissolved out and the preparation is spoilt. When overheated the red corpuscles are apt to stain so deeply that any granules or parasites within them are hidden from view.*

The staining process used for the dried and heated cover-glass preparations is very simple. The cover glass is either allowed to float on a filtered solution of Löffler's alkaline methylene blue or else the staining fluid is dropped upon the cover glass and allowed to remain from one and one-half to two minutes. It is thereupon washed in distilled water and dipped into a one-third per cent solution of acetic acid for an instant to remove any diffuse stain in the red corpuscles. Lastly the acid is washed away in distilled water.† It is then ready for examination in water or for drying and mounting in xylol balsam. Care must be taken to make the action of the acetic acid solution momentary, otherwise the decolorization may go too far.

If we examine the blood of a mild autumnal type of fever every one, two, or three days, as described, certain phenomena appear regularly at certain stages of the anæmia. When the number of corpuscles has fallen to three millions a variable number of enlarged corpuscles appear. While the normal ones measure about 5 or 6 μ in diameter, the enlarged forms will be from 6 to 8 μ in diameter. This is the first change observable, and it appears only when, as stated, the number has fallen to one-half the normal. As the destruction goes on and the number sinks lower, the large cells become more numerous, but they at the same time grow thinner and more delicate. When the number is below two millions, hæmatoblasts or nucleated red corpuscles begin to appear, and their number may be as high as 5 per cent of all corpuscles still in the circulation. It may also be noted at this stage that some of the large corpuscles show one or more small vacuoles in a cluster in the center of the corpuscle. These contain sometimes a barely visible ($\times$ 1000) particle in rapid dancing motion. These phenomena are all the result of the anæmia, as will be shown later, and have nothing to do with the micro-parasite. The variation in size of the red corpuscles is illustrated in Plate IV, Fig. 3, Plate V, Fig. 3, and on Plate IX.

* In place of a hot-air oven kept at the proper temperature by a thermo-regulator the device of Ehrlich may be used. This consists of a Bunsen burner or a small kerosene stove and a strip of sheet copper laid over it. It is evident that at different distances from the source of heat the copper will be of different temperatures. By placing drops of water on it the place where the temperature is 100° C. can be approximately ascertained by the behavior of the water. The cover glasses are laid upon the sheet of copper for a certain length of time at a point corresponding roughly to 120° C.

† If the film has been properly heated (not overheated), decolorizing is quite unnecessary.

When preparations of blood are dried and stained, another set of changes are observed which were hidden in the fresh preparations. These changes are limited to the enlarged corpuscles. When the number falls below 3,000,000, a few corpuscles are now seen among large numbers of others, whose disc is sprinkled over with a variable number of granules which stain deeply in the alkaline methylene blue.* These granules vary in size. In some preparations of blood at this stage, they may be as large as 0.5 μ in diameter, and there may be from 15 to 30 in a corpuscle. A prolonged observation of these granules has suggested the theory that their size depends largely on the rapidity with which the film of blood has been dried. In those portions of the layer which are thinnest and fixed instantly, only small granules are seen; that is, such as are, perhaps, not more than 0.1 μ in diameter. But in those portions of the layer in which the corpuscles are massed two or three deep, the large granules are found, if present at all. The immediate inference is, that the stainable matter diffused through the corpuscle collects into larger nuclei if there is any time elapsing between the shedding and the drying of the blood. This time is longest in the dense portions of the film. (See Plate IV, Fig. 3, Plate V, Fig. 3, and Plate IX.) The granules in a cell are not all of the same size, although there is not much variation in this respect in the same corpuscle. There are cells with very fine granules, and cells with very coarse granules. Cells with granules of intermediate size are also found. The large granules are usually round, and resemble very closely micrococci, but the slight irregularity in form and size disposes one to reject at once the view that they may be micrococci. The large granules closely resemble one of the stages of the micro-parasite of Texas fever, as will be pointed out later on. The small granules do not appear round, but more angular, and even slightly rod-shaped. They are distributed quite uniformly over the disc, excepting in a few cases in which there was a central space free from them. These bodies stain, as nuclei and bacteria do, with basic aniline dyes, and they are not readily decolorized with acids. They are stained by hæmatoxylin and refuse to stain with Ehrlich's acid or neutrophile dyes.

The granular forms are characteristic of that stage of the anæmia in which the number of corpuscles stands between two and three millions. When it falls below 2,000,000 other peculiar forms appear. The enlarged corpuscles grow thinner and larger, more easily distorted when the drying is retarded, and, when stained as above indicated, many of them show a diffuse, rather pale bluish coloration not easily removable by acetic acid. (Plate V, Fig. 1; Plate IX.) Some show instead of this diffuse coloration an aggregation of exceedingly minute granules which might easily give the impression of a diffuse stain. These types are

*It should be borne in mind that under the conditions formulated above the normal red corpuscle does not retain the stain, either in the form of granules or diffusely.

not infrequently accompanied by hæmatoblasts. It must not be understood that the different stages of the anæmia are characterized by the exclusive presence of one or the other of these changed forms. The granular or "punctate" cells may be met with in the various stages of the anæmia. Likewise the diffusely stained forms are in a few cases encountered with the punctate forms before the anæmia has become advanced. But as a rule we meet first with the simply enlarged corpuscles, next with the "punctate" forms, and lastly with the diffusely stained or "tinted"* forms and the hæmatoblasts.

It is not desirable to go into any details concerning the nature of these corpuscles, as this has already been done from the standpoint of general pathology in another publication where the literature is also taken into consideration.† A few remarks are, however, in order as bearing upon an understanding of the disease before us. The various modified forms of red corpuscles, which we have been considering, are perhaps all embryonic or immature forms. They have been hastened into the circulation from their place of manufacture, the red marrow of the bones, to supply an urgent demand created by the destruction of vast numbers of red corpuscles by the Texas fever parasite. This demand grows more and more pressing as the number of corpuscles continues to go down, and consequently more and more immature forms are sent until the hæmatoblasts themselves, the progenitors of the red corpuscles, appear. The reasons for considering them embryonic or immature red corpuscles can not be entered into here. It must suffice to state that a comparative study of the embryonic cells in the red marrow and of these modified corpuscles in the circulation shows them to be the same.

The stainable material in these new corpuscles may be some form of protoplasm imperfectly converted into the discoplasm of the adult red corpuscle. We have already presented the theory that the granules may be derived from the diffusely stained material by a condensation in the shed blood. This, of course, will demand special study. It is enticing to interpret, as has been done, the larger granules as fragments of the nucleus of the hæmatoblasts, but there are no observations directly supporting this view.‡

The same modified or embryonic forms of corpuscles appear in the acute type of Texas fever after the high temperature has disappeared and the stage of convalescence has begun. They disappear speedily from the circulation when the number of corpuscles again begins to rise. In fact they seem to disappear when the number has risen to 2.5

*These terms are used in the appendix to designate these modified corpuscles.

†Theobald Smith: On changes in the red blood corpuscles in the pernicious anæmia of Texas cattle fever. Trans. Assoc. Amer. Physicians for 1891.

‡It is a curious fact that the granular, or "punctate" cells have not been seen in the parenchyma of the various organs (spleen, liver, kidneys), although the diffusely stained or "tinted" cells are present.

millions. Even when the regeneration does not go on quickly and the anæmia remains stationary for a time the punctate and tinted cells speedily disappear while the simply enlarged corpuscles or macrocytes remain in the circulation or rather are produced as such until the number is above 3 millions and they do not regularly disappear until the number is over 4 millions.

While there could be no reasonable doubt that the forms described as abnormal are immature red corpuscles, there was enough resemblance between the larger granules and the smaller stages of the parasite to make a crucial experiment necessary. It might likewise be claimed that the body to be presently described as the micro-organism of Texas fever is nothing more than a phenomenon of embryonic or perhaps degenerated red corpuscles caused by some still unknown agency, which itself is the direct cause of the disease. It became therefore necessary to show that the parasites are not the result of the disease and that in artificial anæmia they do not appear. To prove this, bleeding was resorted to, first upon a sheep then upon a cow. The artificial anæmia brought about caused the various modifications described above to appear in the blood of both sheep and cow, but the various forms of the parasite did not show themselves at any time. These experiments are of sufficient importance to warrant their publication here.

Male lamb, 5 months old, still nursing—gross weight, 65 pounds.

Date.	Number of red corpuscles in a cmm.*	Quantity of blood withdrawn from jugulars.	Remarks.
1890.		*Grams.*	
June 17	11,500,000	336	
June 18	10,500,000	....	Blood corpuscles not visibly altered.
June 19	9,200,000	406	Do.
June 20	6,500,000	....	Do.
June 23	8,000,000	330	Many corpuscles enlarged (macrocytes). A few punctate cells.
June 25	7,500,000	....	20–30 per cent corpuscles enlarged, about 10 per cent punctate.
June 27	8,200,000	160	The same number of macrocytes as before. Punctate cells have nearly disappeared.
July 1	7,500,000	546	Macrocytes as before. No punctate cells.
July 3	6,500,000	441	Do.
July 5	6,600,000	650	30–40 per cent macrocytes. 5–10 per cent punctate and tinted cells.†
July 7	5,600,000	....	20–30 per cent punctate and tinted cells, the latter relatively increased.
July 10	7,100,000	....	Macrocytes diminishing. Punctate and tinted cells absent.
July 15	8,900,000	....	Corpuscles normal.
July 25	8,900,000	....	Do.

* This number was obtained before the bleeding in every case.
† See Pl. IX, Figs. 1 and 2.

Cow No. 168.

Date.	Number of red corpuscles in a cmm.[1]	Quantity of blood withdrawn from jugular.	Remarks.
1891.		*Grams.*	
Aug. 3	6, 762, 500	2, 268	Blood elements not visibly changed.
Aug. 4	4, 988, 700	2, 325	Do.
Aug. 5	4, 652, 700	....	Do.
Aug. 6	5, 227, 800	3, 827	Do.
Aug. 7	3, 820, 000	4, 251	Do.
Aug. 8	3, 094, 600	4, 989	10 per cent macrocytes, 2-3 per cent punctate corpuscles.
Aug. 10	2, 253, 700	....	20 per cent macrocytes, 15 per cent punctate corpuscles,
Aug. 11	2, 143, 000	....	Same as yesterday.
Aug. 12	2, 114, 750	....	Same as yesterday (Plate IX, Figs. 3, 4).
Aug. 14	2, 538, 400	....	Numerous macrocytes. 5 per cent punctate corpuscles.
Aug. 17	3, 202, 000	....	Macrocytes as before. A few punctate corpuscles.
Aug. 22	3, 200, 000	....	Macrocytes as before. No punctate corpuscles.
Aug. 29	4, 325, 000	....	Only a few macrocytes.
Sept. 8	4, 784, 000	....	Do.

[1] This number was obtained before the bleeding in every case.

These two experiments show that the various changes which the red blood corpuscles undergo in Texas fever are solely the result of the rapid and enormous loss of red corpuscles. The enlargement of the corpuscles, the presence of stainable matter in them in the form of large and small granules, and uniformly diffused, are phenomena accompanying severe loss of blood by whatever means this may have been brought about, and are indicative of an active regeneration of the blood elements. We are therefore justified in drawing a sharp line between these phenomena and those to be subsequently described as the Texas fever parasite.

The white corpuscles of the blood did not obtrude themselves so far as fluctuation in numbers is concerned during the various stages of the acute and mild types of the disease. Hence quantitative determinations were not attempted until the latter part of the season of 1891, when Toison's fluid was used.* Both red and white corpuscles were then estimated with little extra labor in the same preparation of blood. In all cases the 400 squares of the ruled cell of the Zeiss apparatus were counted. The number of leucocytes in these spaces is, however, so small (from 3 to 15) that we might anticipate only an approximate accuracy, unless we take the average estimate of 3 or 4 preparations. For this no time could be taken. Hence the figures as given in the appendix based upon the method here described can not be regarded as of much value.†

* See page 37.

† The inefficiency of the method used has been commented upon recently by other investigators who have had occasion to use it. A melangeur is now specially prepared by Zeiss for the estimation of the white corpuscles, and constructed to give a one-tenth dilution of a considerably larger quantity of blood, in order to concentrate the white corpuscles. This was latterly tried but found useless, since the capillary tube is so wide that it no longer retains the column of fluid by capillarity and the blood drops away before it can be mixed with the diluting fluid. We trust that this defect may be speedily remedied.

As far as they go, they indicate not very much fluctuation. Any unusual increase in numbers was not noted in the stained preparations of any case which came under observation. In some cases an abnormal crowding together of leucocytes was observed in dried preparations, which crowding must be regarded as having existed within the blood vessels, for there was no time for any massing together after the blood had left the vessels.

Whether the disease affects the different kinds of leucocytes either qualitatively or quantitatively has not entered into the scope of this investigation. It should be said, however, that in the stages of advanced anæmia when hæmatoblasts are occasionally detected in the circulating blood, peculiar round bodies, which stain deeply and solidly with methylene blue, and which are a trifle smaller than red corpuscles, are frequently detected. A careful comparison of these with the nuclei of the hæmatoblasts makes it safe to regard the former as such nuclei which have been set free in the circulating blood.

THE CAUSATION OR ETIOLOGY OF TEXAS FEVER.

TEXAS FEVER IS NOT CAUSED BY BACTERIA.

We have thus far considered only the changes caused by the disease in the blood and the organs of infected cattle and the manifestation of these changes during the life of the animal and after death. They are the concomitants and the resultants of certain causes at work in the body of the animal and are to us interesting and important only in so far as they shed light upon the nature of these causes. And what are the causes at work in producing Texas fever? This problem has occupied the attention of a number of investigators since 1868. The general belief that Texas fever could be nothing else than an infectious disease due to the multiplication of some minute organism entering the body from without, led to a search for this microörganism by most of those who made this disease a special study. Dr. R. C. Stiles of the Metropolitan Board found in 1868 in the bile of Texas fever "preserved for analysis" minute vegetable organisms "in the form of spherical or irregular aggregations of micrococcus." From bile sent to Prof. Ernst Hallier, of Jena, Germany, this savant cultivated a mold (1, p. 1141–1150). It is needless to go into the details of this investigation, for its methods are exploded and its results fantastical to say the least. Gamgee examined the blood of Texas fever with high powers, but found nothing unusual. Drs. John S. Billings and E. Curtis of the army studied the blood with reference to the presence of cryptogamic growths at about the same time, but their efforts were fruitless.

Dr. D. E. Salmon, in 1883, described a diplococcus obtained from the spleen in cultures, but left its relation to the disease undecided (5, p. 13).

Dr. J. H. Detmers (5, p. 134) mentions the presence of bacilli and micrococci in the liver just after death, but none in the blood.

In a report published in 1888 Dr. Frank S. Billings claimed, somewhat pompously, to have discovered the "true germ" of Texas fever.*

*The announcement of this supposed discovery is entitled to quotation:

"Hence the germ of the southern cattle plague has been discovered, and I think that I may be pardoned the egotism of claiming this to be the first occasion in American medicine that not only one but two germ diseases of animal life have been traced out and their origin placed upon an impregnable basis.

"The order of events seems to be reversing itself! The sun of original research, in disease, seems to be rising in the West instead of the East, so far as America is concerned. This honor does not belong to me alone," etc. (8, p. 72).

This germ is said to be like the germ of Billings's swine plague (hog cholera). It "has been found in the blood, the gall, the urine, the liver, spleen, and kidneys" of every diseased animal that was examined. It produces Texas fever in cattle when inoculated in "unquestionably pure cultivations."

This seems to be sufficient proof. In scientific research, however, especially when an important discovery is involved, it is incumbent upon the investigator to give at least to some extent the details of his experiments, so that others may form an opinion of their own as to whether the work was properly done and the conclusions or inferences warranted. Instead of a conscientious report of work done we find in this bulletin of 138 pages the same padding used in the swine-plague report of the same author. Quotations, criticisms, and discussions, mostly foreign to the object of the report, together with an unwarranted dragging in of yellow fever, constitute the bulk of the text.

The germ of Texas fever as found by Billings stains at the ends. It grows on potato with a delicate straw color, which finally becomes a brick-red yellow. In the beef infusion gelatine tube it does not liquefy gelatine. These meager facts are not sufficient to distinguish this organism from a large group of bacteria living especially in the intestines of all domesticated animals. In fact the few characters apply very well to the *bacillus coli communis*, a universal saprophyte in decomposing organic matter of intestinal origin, and one that has pathogenic properties with reference to smaller animals. This supposition is strengthened by the fact that Billings found in fresh and old manure bacteria not to be distinguished from the supposed Texas-fever germ.

As to the crucial test—the production of Texas fever by the inoculation of cattle with cultures of this germ—one case is reported. A black steer calf five months old presented four days after inoculation a temperature of 42.5° C. (106.5° F.). The temperature remained high for two days, when the animal was killed for examination. A glance at the autopsy notes shows that there is nothing to prove that the disease was Texas fever. In the liver "each acinus was most beautifully demarcated by delicate lines of a bright yellow color, which represented the interacinus and distended gall ducts." In Texas fever the bile injection is, as a rule, limited to the ultimate bile canaliculi within the acinus and rarely extends into the interlobular bile ducts. Was the bile stasis in the intralobular tissue actually seen under the microscope in this case? The important pathognomonic sign of Texas fever—hæmoglobinuria—was absent. The evidence that this steer was suffering from Texas fever is therefore not sufficient by any means, although we do not wish to claim that it was not Texas fever. This latter disease may have been induced by contact with ticks, or by the presence of the Texas-fever parasite in the cultures originally introduced with blood or bits of tissue. The total absence of any experimental details as to what culture was used, how it was injected, where the animals came from, etc., leaves us wholly in the dark as to the accuracy of the experiment.

These are all the facts of importance communicated by Billings in his report on the supposed bacterium of Texas fever.* Even if the evidence to be adduced farther on were not diametrically opposed to them, the meagerness and vagueness of the statements made by him would prevent any candid unbiased observer from accepting them without great reservation. As to some other theories presented by Billings in his report, we shall recur to them farther on.

In May, 1890, a bulletin on Texas fever was published by Dr. Paul Paquin, of the Missouri Experiment Station (9), which describes investigations conducted between September, 1888, and March, 1890. Paquin claims to have found a germ, but it is impossible to discover from the descriptions anything concerning the nature of this germ, excepting perhaps that it does not exist, and that a variety of microscopic things were seen in the débris of the blood, bile, and liver, which were considered by the author without any supporting proof as the Protean forms of a single organism. This kind of logic may suit disappointed observers, but it does not contribute anything to our knowledge of the subject. Moreover, in departing from established methods † and in describing forms presumably existing which are wholly unlike any already recognized, the burden of proof rests upon the author and the work must be unusually well done to merit any attention. The conclusions reached by the author and presented on page 43 of the bulletin have none of them received even the shadow of a proof in the text. That bacteria may be found in cases of Texas fever is unquestioned, but that they have anything whatever to do in producing the disease demands rigorous proof. It would be difficult therefore to analyze a report of experiments, however conscientiously pursued, in which the fundamental elements of scientific research—a careful record of such experiments and their details and sound logic in drawing conclusions from such experiments are at fault. We refer here only to the work involved in the study of the cause of the disease. The vaccination theory will be discussed farther on.

In the third annual report of the Arkansas Experiment Station (1890), Dr. R. R. Dinwiddie reports that in a large number of cultures on different media from three cases of Texas fever no bacteria de-

* After the above was written an article by Billings on the etiology of southern cattle plague (Texas fever) appeared in the Journal of Comparative Medicine for 1892, beginning with the July number. The remarks in the July and August numbers may be passed over without comment. In the September and October numbers is contained practically what has been stated above, largely drawn from his report. There is quoted in addition an experiment with cultures from ticks with which he claims to have produced Texas fever. While we are pleased to see that, since reading preliminary articles in the reports of the Secretary of Agriculture, Billings is now paying some attention to ticks, we must wholly dissent from his conclusions, which are practically the same as those reviewed in the text. The conclusions which we have drawn and those presented by Billings in these articles may be safely left to the judgment of future workers in this field.

† See p. 8, which describes the method of preserving tissues.

veloped. He also isolated bacteria from the intestines which proved negative when inoculated.

In our own work the first problem which naturally presented itself was to determine whether bacteria could be regarded as the cause of the disease. Hence the very first and some of the later cases were utilized for this purpose. As to the first postulate necessary to be fulfilled in demonstrating the cause of any infectious disease—to find with the microscope the bacterium or other organism in the body of the diseased animal—this failed utterly in all the cases examined. The thousands of cover-glass preparations of the blood, spleen, liver, kidneys, etc., examined fresh and stained never showed any bacteria excepting when the animal had been dead for a number of hours. Animals killed in a dying condition were almost invariably free from bacteria. Those which succumbed in the night in midsummer contained usually large bacilli which are denominated post-mortem bacilli in the appendix, and which are familiar to every worker in bacteriology. They are specially abundant in the carcasses of large animals, from the pig up, which have been dead some time; probably because a large carcass remains warmer and more thoroughly deoxidized than a small one, and thus becomes a good medium for this anaërobic bacillus to flourish in. This bacillus does not grow in ordinary culture tubes, excepting perhaps very feebly in the bottom of bouillon tubes and in impure cultures on agar-agar. These bacilli are mentioned as being present in Nos. 5, 6, 65, 106, 129, 144, 164, 169, 180, 227. They are somewhat broader than anthrax bacilli, have rounded extremities and usually occur single. They stain readily and deeply in all aniline dyes. The mention of this familiar intercurrent bacillus might have been passed over were it not that observers who have described bacteria in connection with Texas fever may have occasionally mistaken this as the cause (9, p. 43, third conclusion).

As to the cultivation of any bacteria from the blood and tissues in Texas fever, the results are equally negative. Special attention was paid to this phase of the problem in 1888. In the appendix will be found a brief statement of this work under the six first cases and after the sixth a summary of the results obtained with a bacterium which appeared a number of times in the cultures. That it was the ordinary *bacillus coli communis* of the intestines which had found its way into the liver and thence into other organs there can be no doubt, for subsequent comparisons with *bacillus coli* from the intestines of healthy cattle proved them to be identical. It should also be remembered that this bacillus was present in exceedingly small numbers, as will be seen from the quantity of tissue or fluid used for inoculating the various culture media and from the fact that they were never seen in cover-glass preparations. A large series of cultures were also made from several cases of the disease in 1889 and 1890 with equally negative results. In most cases the cultures remained absolutely sterile. In

some a few cultures developed, the contents of which were explainable either as contaminations or as coming from an animal in which frequent skin incisions in the last stages of the disease may have led to the introduction of a few bacteria into the circulation. The results obtained from cattle infected by Texan animals were as negative as those from North Carolina cattle. (See No. 128.) Cultures have thus far been made from four different outbreaks, and the blood and the tissues have been examined microscopically from as many more. (See Nos. 1, 2, 3, 4, 5, 6, 43, 44, 48, 54, 70, 128.)

We are, therefore, ready to admit that there are no bacteria in the blood and tissues of animals suffering with Texas fever, excepting occasional individuals which probably enter the circulation from the intestines by way of the disintegrated liver. But may there not be bacteria living only in the intestinal tract which send their toxic products into the circulation and thus cause disease? This hypothesis might be attractive to those who will insist on bacteria as the cause of Texas fever, but there are no facts to support it, and in view of the more definite results obtained by us its discussion is useless.

THE MICROÖRGANISM OF TEXAS FEVER.

(*Pyrosoma bigeminum, n. sp.**)

Although Texas fever is essentially a blood disease, and only secondarily affects the spleen, liver, and kidneys, most observers have failed to recognize this fact. R. C. Stiles (1) was the earliest and the only observer who laid any stress upon the changed condition of the blood corpuscles. He says: "The red blood corpuscles when examined immediately after removal from the body were shriveled and *crenated* without artificial provocation. * * * In one case many of the disks appeared to have lost a portion of their substance, as if a circular piece had been punched out, the addition of water failing to restore the disk to completeness." There can be little doubt that Stiles saw at that time the microörganism of Texas fever, without, of course, recognizing it, since this description applies very closely to the appearance of red corpuscles infected by this micro-parasite when the blood and the parenchyma of liver, spleen, and kidneys are examined fresh soon after death. Other observers have examined the blood, but have seen nothing unusual.

In 1888 during the examination of portions of the organs of cases Nos. 3 to 6 inclusive the destruction of the red corpuscles seemed to be the one prime phenomenon of the disease. The large quantity of hæmoglobin in the urine, and the peculiar condition of the liver and

*For the preliminary announcement of the discovery of this microörganism see the Annual Report of the Secretary of Agriculture for 1889, the Medical News for December 4, 1889, or the Proceedings of the American Public Health Association for 1889.

the bile indicative of hyper-secretion could not but lead to the hypothesis that there was some destructive agency at work in the blood. R. C. Stiles in 1868 assumed the liver to be the primary focus of the disease and believed that the alteration of the blood elements was due to the absorption of bile from the liver into the circulation. This inference from the observed pathological phenomena is erroneous, for the liver is doing too much work rather than not enough, and the destruction of blood corpuscles goes on very early in the disease. The outcome of the work in 1888 was the formulation of several theories as to how the blood corpuscles came to their destruction:

(1) There may be organisms in the blood which by the production of toxic products act directly on the corpuscles.

(2) There may be some toxic substance in the digestive tract which is absorbed into the blood and causes a dissolution of the red corpuscles. This substance may be the product of specific bacteria multiplying only in the digestive tract.

(3) There may be micro-parasites which invade the red corpuscles in a manner similar to those of malaria, and which by their growth disintegrate the containing corpuscle.

The first hypothesis was soon made improbable by the absence of any demonstrable organisms in the parenchyma of the various organs which are abundantly supplied with blood, such as the liver, spleen, and kidneys. To test the second the contents of the digestive tract, more particularly the small intestine, were carefully examined microscopically in 1888 and many plates and rolls of gelatine were made with the intestinal contents without bringing to light any other than the ordinary intestinal bacteria. It is true that this method was merely preliminary and would have been followed by more exhaustive bacteriological studies of the digestive tract had not the third hypothesis furnished the clue. This, however, could not be tested in 1888, since no living animals were accessible, and the results of the study of the blood elements could not be considered reliable when obtained only from the organs of animals dead twenty-four hours or even longer. In the very first case which succumbed on the experiment station at Washington, in 1889, certain microörganisms were found within the red corpuscles which will now claim our attention. It should be said, however, that these bodies were noticed in the spleen of a case as early as 1886, as will be seen from the notes of No. 2, of which only this organ was brought to the laboratory.

PECULIAR BODIES FOUND IN THE RED CORPUSCLES OF HEALTHY CATTLE.

In endeavoring to prove the existence of specific parasites in the blood as causes of disease it becomes necessary to prove their absence during health. A large series of microscopic observations have been made upon the blood of cattle which were not infected as well as upon

those which were infected before the disease had appeared and after it had passed away. In a preceding chapter we have treated of the number of red corpuscles in health and in Texas fever, also the changes which they undergo in this disease and the methods to be used in studying them. These methods apply in the study of the microörganism and the reader is referred to them (p. 43). The red corpuscles of cattle retain their form pretty well when examined in the fresh condition. After a time small conical protrusions form on them as they shrink and shrivel, and the stramonium forms begin to appear.

In 1890 certain minute bodies were first observed within red corpuscles of cattle in health. They are present in variable numbers. In some cases they are not found even after prolonged examination of cover-glass preparations (apochrom. 2 mm. oc. 4 or 8). In some a few may be seen in a single field. In several cases as many as 10 per cent of the corpuscles contained them. They may appear as barely visible points with a bright luster. Whether this brightness is a resultant of the color of the body itself and that of the corpuscle within which it is lodged it is impossible to find out. Suffice it to state that as we look into the microscope at a corpuscle containing one of these bodies it appears as a bright, almost golden, speck. These bodies are not all of the same size and form, although their minuteness makes it impossible to express differences in figures. They range in size from mere specks to quite appreciable coccus-like bodies. Frequently a rod-like form with a central constriction, reminding one of diplo-bacteria, appears. It may be that the rod-like forms are observed as round bodies when standing on end within the corpuscle. In general they are rarely 0.5 μ large, usually much smaller. In the table of the appendix they are indicated provisionally as bright bodies. Plate VI, Fig. 9, gives an approximate idea of the relative size of these bodies. The third and the fourth corpuscle contain bodies which are much too thick, however.

Another interesting phenomenon of these bodies is their occasional motility. Many change their place within the corpuscle. When first detected the speck is usually situated at the periphery of the corpuscle. When watched closely for a few minutes it may be seen to move toward the center of the corpuscle, then back again toward the periphery. Then the movement may be along the periphery for a distance, succeeded perhaps by a movement across the entire corpuscle. The smallness of these bodies does not allow us to state whether this movement is passive and due to currents within the corpuscle or whether it is the active, spontaneous movement of a living organism. There are, however, cases in which it is difficult not to accept the view that the movement belongs to a living body. The warm stage seems to accelerate these movements, but since heat is also likely to cause disturbance of the fluid within the corpuscle, this acceleration does not add to the proof that we have organisms before us. Fig. 10 on Plate VI shows the path of one of these motile bodies. They do not

reappear in dried and stained preparations, which means that they do not stain.

It has already been stated that these bright specks are present in the red corpuscles of healthy cattle. They are found in all seasons of the year and in most animals examined, in southern (North Carolina and Texas) as well as native cattle. Besides these bright bodies, many of which are constantly changing their places within the corpuscle, there are occasionally seen in the fresh blood, both in health and during the fever period of this disease, bright rod-like bodies within corpuscles, which do not change their place. They lie usually at the edge of a paler area within the corpuscle, and the impression is conveyed that they are crystals derived from the hæmoglobin of the adjacent pale spot. There are from two to four of these minute rods in the affected corpuscle.

In addition to these intraglobular bodies present in healthy blood, certain forms are now and then seen in dried preparations stained in methylene blue which might be mistaken for Texas fever parasites. They are round, deeply stained coccus-like bodies situated quite near the periphery of the corpuscle and about one to two μ in diameter. There is never more than one in a cell. They differ from the intraglobular parasite by a deep blue stain and by the compact round form. They are probably remnants of the nucleus of the ancestor of the corpuscle—the hæmatoblast.*

THE MICROÖRGANISM IN THE ACUTE TYPE OF TEXAS FEVER.

In describing the micro-parasite of Texas fever we shall describe the various forms and stages as they are met with in actual examinations first and then construct its life history as far as that is possible from the recorded facts.

In fresh blood of the acute disease during life.—When blood is drawn

* The interpretation of appearances in the field of the microscope is frequently beset with difficulties, and certain foreign bodies are likely to intrude and give rise to false impressions. To those accustomed to the examination of the blood elements this is not likely to happen, but to the beginner in this work certain suggestions will not be superfluous. In preparations of fresh blood from cattle a large number of very minute refracting spherical bodies about as large as the earlier stages of the Texas fever parasite are frequently found in all parts of the preparations. They may be attached to the disks of many corpuscles and appear like intraglobular bodies. Their presence in other parts of the field free from corpuscles as well as careful focusing shows them to be foreign bodies. Prolonged observation has led to the inference that they are derived from the fat in the sebaceous follicles of the skin, because they have been occasionally encountered in masses on the slide. The incision perhaps dislocates such masses and the blood carries them out.

In stained preparations bluish spots are not infrequently found on red corpuscles which might be mistaken for parasites. They are nothing more than blood plates which have attached themselves during the drying of the film to the corpuscles. In general it may be said that such misinterpretations will not occur after the various stages of the micro-parasite have been once recognized.

from the skin during the fever and examined at once with high powers (500 to 1,000 diameters, Zeiss apochrom., 2mm., oculars 4 and 8) certain corpuscles will be found containing two pale bodies of a pyriform outline. One end of each body is round and the body tapers gradually to a point at the other. They vary somewhat in size in different cases, but the two bodies in the same corpuscle are as a rule of the same size. They are from 2 to 4 μ in length and 1.5 to 2 μ in width at the widest portion. (Plate VI, Figs. 4, 5, 6.) Their tapering ends are directed toward each other and usually close together; their rounded broad ends may occupy various positions with reference to each other. They may be seen together with the axes of the bodies nearly parallel or they may be far apart, the axes forming a straight line. (Plate V, Fig. 2.) The bodies themselves have a homogeneous, pale appearance, contrasting markedly with the inclosing red corpuscles from which they are sharply outlined. There is no differentiation into peripheral and central zone, no granular appearance of the body. Several slight variations in the appearance of these bodies at different times have been noted. The smaller forms are as a rule homogeneous; the larger forms are very frequently observed to be provided, in the rounded end of the pyriform body, with a very minute spherical body probably not more than 0.1 to 0.2 μ in diameter, which contrasts dark with the body itself. In several cases it manifested a brilliant luster with very high powers. (Plate VI, Figs. 4, 5; Plate VIII, Figs. 4, 5.) In the largest pyriform bodies there was seen in the center of the enlarged end a somewhat larger round or oval body which seemed to take the place of the smaller body or else be associated with it. This second body was from 0.5 to 1 μ in diameter. It changed its appearance with the focus. At a low position of the objective the parasite appeared dark with a light round spot in the enlarged end. At a higher position of the objective the inner body appeared dark, inclosed in the lighter pyriform outline. One or both of these bodies were observed in some of those forms undergoing amœboid changes.

A question of considerable interest to be discussed farther on is the relation of these two pyriform bodies to each other in the same corpuscle. Any direct mutual connection of their tapering ends is not demonstrable in the fresh preparation.

When exposed to a temperature of 35° C to 42° C on the warm stage* some of these bodies, by no means all, exhibited changes of outline.

*Pfeiffer's warm stage as constructed by C. Zeiss was used. The entire microscope is inclosed in the box (with exception of ocular and adjustment screws). The heat is communicated to the heavy iron bottom of the box and thence to the air and the microscope stand which rests upon it. The drawback to this apparatus is the large amount of heat which is stored in the iron base and which may cause the temperature of the stand to rise faster than that of the surrounding air. As these observations upon the fresh blood had to be made mainly at the experiment station with no gas at hand, the heat was applied with an alcohol lamp and the thermometer carefully watched.

These may go on continuously in some bodies, in others quite slowly. The motion most frequently exhibited consists not so much of a thrusting out and withdrawing of pseudopodia as of a continual recasting of the general outline of the body as we find it for example in the leucocytes of mammalian blood. (Plate VIII, Figs. 1, 2, 3.) The changes of form may go on so continuously and so rapidly that it is not possible to sketch them all, as some escape observation during the sketching. The motion described does not of necessity require the stimulus of heat. During the past summer the same continuous rapid changes were observed in preparations of blood, sealed with paraffin, at 75° and at 85° F. In the former case the slide had been prepared at 10:45 a. m. The motion was still noticeable at 3:10 p. m., when the observation was discontinued. In the latter case the observation was discontinued six hours after the drawing of the blood, although the motion had not yet ceased. The sparseness of the micro-parasite in the blood makes it impossible to state definitely whether this amœboid motion belongs to a certain stage of its life. On the whole the observations tend toward the inference that the pyriform bodies do not change their form and that the motion belongs to a younger stage. It should likewise be stated that the amœboid bodies observed were apparently single within the corpuscle.

If dried cover-glass films, heated, stained in alkaline methylene blue and decolorized as described on p. 44 be examined in water or balsam—preferably the former—it will be found that the forms described have become stained. The staining, however, is more feeble than in those micro-parasites found in the internal organs after death. It is limited usually to a zone on the periphery of the body, the center being feebly blue or entirely free from coloring matter. (Plate V, Fig. 2, 3*d*; Plate VI, Fig. 7.) In the latter condition it has been observed that these circulating forms have a peculiar luster, as if they possessed (in the dried and stained condition) feebly refracting powers. Other basic aniline dyes, such as methyl violet and gentian violet, are equally applicable. Fuchsine stains the organism, but also affects the containing corpuscle, so that the pictures obtained with it are not satisfactory. Hæmatoxylin likewise stains the organism fairly well. In general the clearest, most distinct pictures have been obtained with Löffler's alkaline methylene blue.

The intraglobular parasites found in the acute stage are not all pyriform and paired. In fact a considerable number as seen in stained preparations are somewhat irregular in outline and single. These are probably the bodies which were undergoing amœboid changes when they were dried in the film on the cover glass. Some of these irregular forms are shown on Plate V, Fig. 3.

The corpuscle which contains such a pair of microparasites has fully one-fourth of its area occupied by them. That this invasion is detrimental to the corpuscle is easily understood. In preparations of

fresh blood the corpuscle has a peculiar appearance. Its margin is irregularly notched and creased, the border may be beset with projecting spine-like processes and its color may be darker than that of the normal corpuscle. It has, to use a fitting expression, a wrecked appearance. This change is more marked in some cases than in others. Such corpuscles have lost their characteristic flexibility. They retain their disc-like form, even after normal corpuscles have become shriveled and folded in preparations kept under observation for some time.

The number of infected corpuscles circulating in the blood during the high fever is usually quite small. It is difficult to make an approximate estimate without careful counting. Probably one or two in a single field of the 2-mm. objective, or from half to 1 per cent is near the truth in most cases. In some, however, a long search is necessary before one is brought into view. When the number grows larger, death is not far distant and may be expected within twenty-four hours. Toward the fatal termination, there may be from 5 to 10 per cent of the corpuscles with the pyriform parasites present. Fig. 2 on Plate V is an illustration of a group of such infected corpuscles taken from the blood on the last day. Very rarely large numbers of parasites may be present and yet the animal recover. The only case of this kind is No. 49, in which hæmoglobinuria appeared at the same time. When present in considerable numbers in the blood the infected corpuscles usually appear in groups in the field of the microscope, as is shown in the figure referred to, and not uniformly distributed.

When the fever has subsided and the number of red corpuscles has been greatly diminished, the parasites disappear quite rapidly from the blood. In fact, the reduction of temperature usually coincides with the more or less complete disappearance of the infected corpuscles, and their place is then taken by the large number of embryonic corpuscles which begin to replace the losses. An occasional infected corpuscle may be detected for some days or even a week after recovery has set in. But they are so scarce that their detection is more of an accident. After the subsidence of the fever, when there is a general sinking of the vital powers, leading to death, the parasites may linger on in the blood in small numbers or they may disappear as in recovering cases.

Parasites in internal organs.—With only 1 or 2 per cent, or even 10 per cent, of infected corpuscles in the circulating fluid, it would be difficult to account for the enormous daily losses of blood corpuscles in the acute fever. The difficulty is cleared up by sacrificing an animal in the earlier days of the fever and examining the internal organs for infected corpuscles. Large numbers of parasites are found within corpuscles in the capillary blood of congested areas, such as those of the heart muscle and of the omentum. In the latter membrane there are delicate fringes containing capillaries which may be placed entire on a slide and examined with the highest objectives. In such capillaries in the fresh condition, with perhaps a little iodized serum added, the pale

intraglobular parasite may be seen quite distinctly. When such fringes are torn and crushed on cover glasses and dried films prepared and stained, the large number of parasites is at once revealed. (Plate VI, Fig. 1.) The same may be said of the muscular walls of the heart. In these the smaller vessels are seen by the unaided eye to be engorged, and in sections the capillary network is found in the same condition. (Plate VI, Fig. 2; Plate VII, Fig. 1.) If a piece of such muscular tissue be compressed and dried films made from the blood squeezed out, an unusually large number of infected corpuscles will be found.* These statements are best illustrated by a case:

No. 163 was killed August 25, 1891, when her temperature was 107. On the morning of August 21 her temperature was still normal (101.6). It was not taken until August 24, when it was 106.8. If we assume that the first high morning temperature occurred August 22, she was killed at the end of the third day of continued fever. Even at this time there had been great losses in blood corpuscles.

August 13	5,000,000 in a cmm.
August 24	3,338,800 in a cmm.
August 25	2,645,000 in a cmm.

Before she was killed there were 2 to 3 per cent of infected corpuscles in the circulating blood. In the internal organs there were found in cover-glass preparations made at the autopsy—

In blood from skeletal muscles very few infected corpuscles.
In blood from the right heart very few infected corpuscles.
In blood from marrow of sixth rib very few infected corpuscles.
In blood from the left heart 2 to 3 per cent infected corpuscles.
In blood from lung tissue 2 to 3 per cent infected corpuscles.
In spleen pulp 5 per cent infected corpuscles.
In liver tissue 10 to 20 per cent infected corpuscles.
In kidney tissue 10 to 20 per cent infected corpuscles.
In hyperæmic fringes of omentum 50 per cent infected corpuscles.
In heart muscle 50 per cent and many free parasites.

This distribution of the infected corpuscles and their localization in the capillaries will receive more attention later (Plate VII). Meanwhile we simply wish to point out that, while only a few parasites may circulate in the blood, the infection may reach 50 and even more per cent in the internal organs. The parasites as they appear in the capillaries differ somewhat in form from those in the circulating blood. Their form may be best seen in dried and stained preparations of the capillary blood of the heart muscle. (Plate IV, Fig. 5.) They appear slightly smaller than in the circulating blood and the outline of many is spindle-shaped or fusiform, *i. e.*, tapering at both ends. (Plate VI, Fig. 1.) In this stage, which is probably one of active growth, they stain very well. The stain is deeper in that half of the body directed towards its mate in the same corpuscle. Distinctly pyriform bodies are also present,

* In such preparations, the falciform bodies of sarcosporidia cysts are frequently present, especially when the preparation is from a cow over 5 years old.

and these as a rule take the stain quite uniformly. In preparations of fresh blood from the same source no differences are observed except an absence of the minute nuclear (?) body in this stage. It may be that we have to deal with forms younger than those which circulate in the blood (see Fig. 3, p. 70).

Changes of form of an amœboid nature have already been referred to. If the organs of an animal which has been dead for five or six hours be examined it will be found that all the intraglobular parasites have a roundish form and that distinctly fusiform or pyriform bodies are to be seen only occasionally in preparations from the heart muscle. (Plate V, Fig. 1.) The inference is that the microörganisms have assumed the spherical form under the adverse conditions presented by the death of the host. Similar changes are observed after a time on the warm stage. The pyriform and spindle-shaped bodies which have been thus far described may therefore escape the attention of those who study the blood and the organs after death only. The blood is rarely in a condition to be examined after death, because the corpuscles lose their disc-like form very speedily. In the various organs they are preserved fairly well even for hours after death.

The relative number of infected corpuscles in the internal organs demands some attention. This was estimated approximately in dried and stained cover-glass preparations after examining a large number of fields. The cover-glass films were made like those from the blood. A smooth, fresh incision was made into the organ, the cover glass gently drawn over the cut surface, and the film allowed to dry. This gave thin and uniform films. The very soft and partly disintegrated spleen pulp required some other procedure. A little of the pulp was scraped up with the edge of one cover glass and then quickly drawn over another, as in the preparation of blood films. This usually insured layers thin enough for microscopic examination.

A comparison of the various cases in the appendix will show that there is a considerable variation in the number of infected corpuscles found in the body after death, according as the animal succumbed in the fever stage or after the number of red corpuscles had been greatly reduced and the fever had passed away. In the former case the infection is very extensive, as the following illustrations show:

No. 128 (Texas infection).

Blood from skin and heart, 10 to 20 per cent corpuscles contain parasites.
Blood from spleen, 10 to 20 per cent corpuscles contain parasites.
Blood from liver, 40 to 50 per cent corpuscles contain parasites.
Blood from kidneys, 80 to 90 per cent corpuscles contain parasites.

No. 130 (North Carolina infection).

(Number of corpuscles two days before death, 3,922,000.)
Marrow of rib, 5 per cent of corpuscles contain parasites.
Blood from skin and heart, 10 to 15 per cent corpuscles contain parasites.

Blood from spleen, 10 to 20 per cent of corpuscles contain parasites.

Blood from liver, 20 to 30 per cent of corpuscles contain parasites.

Blood from kidneys, 60 to 80 per cent of corpuscles contain parasites.

Capillary blood from heart muscle, and omentum, 50 per cent of corpuscles contain parasites.

In those cases in which the number of corpuscles has fallen quite low, *i. e.*, below 2,000,000 before death, the number of such as are infected must necessarily be low because there are so few corpuscles remaining. Of these the majority may be embryonic or new forms.

No. 184. (Temperature on the last day, 103.2; number of corpuscles, 1,822,500.)

Blood (subcutaneous and from heart cavities) contains ½ to 1 per cent infected corpuscles.

Spleen, 2 to 3 per cent infected corpuscles.

Kidney and liver, 20 to 30 per cent infected corpuscles.

Heart muscle, 10 to 15 per cent infected corpuscles.

No. 95. (Chronic case. Infection first detected August 7; killed in dying condition August 25. Blood corpuscles 1,858,800.)

Blood before death contains 5 per cent infected corpuscles.

Spleen contains 2 per cent infected corpuscles.

Kidney and liver contain 5 per cent infected corpuscles. The former organ also contains many freed parasites.

These illustrations may suffice here. Many more may be found in the appendix to demonstrate the variable number of infected corpuscles found at the autopsy. As to their distribution over the body, something has already been stated. They are very abundant, as determined thus far, in the capillary blood of the heart muscle, but quite rare in that of the skeletal muscles. Of the internal organs the kidneys usually contain the largest numbers; not infrequently from 50 to 80 per cent of all the corpuscles are infected. (Plate IV, Fig. 4; Plate VII, Fig. 2.) Next comes the liver, then the spleen. In spite of the fact that this latter organ is loaded by several times its own weight with red corpuscles, rarely more than one-tenth contain parasites. Infected corpuscles have been found in great abundance in the capillaries of the choroid plexus of the lateral ventricles of the brain and in the vessels of the pia and the brain substance. They have also been detected in the capillaries of the intestinal mucosa.

Freed parasites.—In view of such enormous destruction of red corpuscles the question naturally arises whether freed forms of the parasite are not regularly observed. In the circulating blood none have been seen. In the preparations from the heart muscle of various cases there are seen a large number of free bodies in pairs as they are found in the corpuscle. Unstained, they float in pairs in the blood under the cover glass, sometimes as pyriform, sometimes as round bodies. (Pl. VI, Fig. 8.) They have a homogeneous grayish appearance. Whether there is at this time any organic connection between the pair by their tapering ends or simply by invisible remnants of the once enveloping corpuscle has not yet been made out. In some instances the shadowy outline of the corpuscle may still be seen around them. Motion has not

been observed. The only other organs in which free bodies are found are the kidneys. (Plate VI, Fig. 3, and notes on Nos. 47, 50, 66, 69, 74, 95, 128, 134, 139.) These organs are generally filled with infected corpuscles. In the fever stage we may find in dried films and in stained sections very few corpuscles which do not contain a pair of parasites. When the number of corpuscles has fallen quite low before death and the destruction has practically ceased there may still be found, in dried and stained films of the parenchyma, immense numbers of free parasites. They appear as roundish coccus-like bodies grouped in pairs and varying slightly in size, never as pyriform or fusiform bodies. To a casual observer they might appear as coarse granulations of broken-down cells and cell nuclei, but a little study and comparison of different cases soon dispels this view.

THE MICROÖRGANISM IN THE MILD TYPE OF TEXAS FEVER.

We have thus far considered only those forms of the parasite found in the acute type of the fever. This type will now be understood to be one in which there is a very rapid multiplication of the micro-parasite in the blood vessels corresponding to an equally rapid disappearance of the red corpuscles. The forms of the micro-parasite are pyriform and fusiform bodies chiefly intraglobular, occasionally free. The post-mortem forms are roundish. In size the pyriform bodies are quite large, and the question arises: are there any smaller forms to be found? For these we must turn to the mild (usually autumnal) cases of the disease. It is an interesting fact that these cases are characterized by the presence of the smaller stages of the parasite. While the pyriform bodies are not entirely absent they are very rare. In the acute type only the latter and not the former are seen.

In the mild type (see p. 22) we have from 5 to 50 per cent of the red corpuscles in the circulating blood infected for a period of from one to five weeks. In the acute type, on the other hand, the circulating blood contains usually from one-half to 2 per cent of infected corpuscles; 10 to 15 per cent is a rare occurrence, usually just before death. In the fresh preparations of blood this small stage of the parasite is as a rule invisible. Rarely we may observe it on the very border of the corpuscle as a round pale spot about 0.5 μ in diameter, which does not change its place. When dried films of blood are stained in alkaline methylene blue the parasites appear as round coccus-like bodies from 0.2 to 0.5 μ in diameter and situated within the corpuscle on its border. They sometimes appear as if situated on the border but outside of the corpuscle. As a rule only one is found in a corpuscle. (Plate IV, Fig. 1, 2, 3.) In many cases a division of the coccus-like body into two could be clearly made out. The separation was noticeable as a paler line and a constriction at either end similar to the division of certain micrococci. This division usually appeared in all bodies of a preparation from one

case, but could not be noticed in any preparation of perhaps the next case.

These bodies stain as well as the larger pyriform bodies in basic aniline dyes and in hæmatoxylin. They do not stain in acid dyes such as eosin or in Ehrlich's dye for neutrophile granules. When this stain is employed the corpuscles, beautifully tinted, show a small round unstained spot where the parasite is situated. When the dried films are treated with dilute acetic acid the corpuscles fade out, while these coccus-like bodies remain behind and stand out prominently.

It has already been stated that these bodies are characteristic of the mild, autumnal type of the disease. A glance at the appendix will show how numerous these cases may be. This stage of the parasite is there indicated provisionally as "peripheral bodies" or "peripheral coccus-like bodies." A more careful examination of these cases will reveal three groups:

(1) Animals exposed to Texas fever late in the season (October and November).

(2) Animals which have passed through an acute attack earlier in the summer (second attack or relapse in October and November).

(3) Animals which contract a mild disease during or previous to the season of the acute disease.

In the first group (see Nos. 47, 48, 51, 52, 53, 56, 64, 65, 66, 69, 82, 85, 86, 89, 93, 95, 100), the disease is mild and may pass unnoticed. The corpuscles with peripheral bodies appear in the blood as the number of corpuscles begins to fall, and disappear when it again begins to rise. Rarely a corpuscle with a pair of large pyriform bodies is detected.

In the second group the phenomena are the same. (See Nos. 49, 64, 104, 105, 107, 160, 206, 219, 222, 230.)

To the third group belong a few cases which showed a blood infection several weeks before the fever appeared among all the susceptible animals in the infected field. (See Nos. 66, 69, 95, 129.) In No. 66 the infection was at first by peripheral coccus-like bodies. This, after a week's time, developed into an acute fatal infection, in which only the large forms were found after death. The same is true of No. 69. In No. 95 the infection by peripheral cocci was noticed as early as August 7. From 10 to 20 per cent of infected corpuscles circulated in the blood until August 19, when some large pyriform bodies made their appearance. The blood contained both small and large parasites until August 25, when the animal was killed in a dying condition.

In the foregoing it has been tacitly assumed that these intraglobular coccus-like bodies are living organisms. This position without further proof would undoubtedly be open to objection, and hence the reason for considering them parasites will be discussed somewhat in detail. In a foregoing chapter (p. 42) all those changes which the red corpuscles undergo as the result of anæmic conditions have been described. Certain corpuscles when dried and stained presented numerous granules

which varied more or less in size, the largest rarely exceeding 0.5 μ. The coccus-like bodies resemble the larger granules very closely, and it might be argued that they are of the same origin. This is not so, however, for the following reasons: The coccus-like bodies appear *with or immediately before* the destruction of red corpuscles. The granules (or punctate cells) appear *after* the number has fallen below one-half the normal, and when the destruction ceases the punctate cells still persist or increase and the coccus-like bodies disappear. The coccus-like bodies are with rare exceptions included in normal corpuscles; the granules belong to the large new cells (macrocytes). As to the bodies themselves, they are all of the same size in the same preparation of blood, while the granules vary considerably in this respect. Again, the granules are present in considerable numbers in the same corpuscle, while the coccus-like bodies are present singly or in a state of division; rarely two are found in the same cell.

When dried films are treated with one-half to one per cent acetic acid the coccus-like bodies come out distinctly as the cell fades. The granules can not be made to appear in this way. Finally the punctate cells can be produced by artificial venesection, but the coccus-like bodies do not appear in the blood under this condition. The coccus-like bodies are thus of a character entirely different from that of the granules, although they take the same stain and appear together in the blood. (Plate IV, Fig. 3; Plate IX, Fig. 5.) Many of the same reasons will also apply in refuting the possible objection that they may be the result of disturbances of the blood other than those of a loss of corpuscles. Heinz * found certain bodies stainable in methyl violet appear in the red corpuscles of rabbits twenty-four hours after the subcutaneous injection of phenyl-hydrazin and its derivatives. These bodies are described as "strongly refracting spheres which are attached, button-like, to the red corpuscle. Often they are connected with it by a pedicle, or they may be entirely free in the plasma surrounded by a shred of protoplasm." In Texas fever the corpuscles containing the coccus-like bodies are always of normal form and appearance. It would be difficult to find reasons for believing them to be the result of some chemical action on the blood corpuscles. The ticks, which might be regarded as secreting a poison in their parasitic life, are very scarce on the animals during the autumn and early winter, when the mild type of disease prevails. When they are most abundant, during the period of the acute disease, the coccus-like bodies give way to the pyriform bodies.

If we admit their parasitic nature as highly probable we have still the question before us whether they are stages of the Texas fever parasite or of another parasite transmitted with it. This question can not be positively answered until, by methods akin to those of bacteriology, we shall be enabled to isolate the Texas fever organism and ob-

* Arch. f. path. Anatomie, CXXII, S. 112

serve the transformation of one stage into the other, either in cultures or in the blood of inoculated animals. In the absence of such rigorous proof the presumption is nevertheless strongly in favor of the unity of this and the larger forms already described. We observe in the first place the appearance of both types of the disease in all outbreaks studied at the experiment station since 1889, though at different periods of the same season, the coccus-like bodies being associated chiefly with cool weather. An outbreak produced after the middle of September in 1889 developed cases containing the coccus-like bodies only (Nos. 47, 48, 51, 52, 53, 64, 65). In one of these cases (No. 48), killed in a dying condition, the spleen and liver were affected as in acute cases, but hæmoglobinuria was absent. There are a few (Nos. 66, 69, 95), already referred to, in which there is a transformation of the mild into the acute type with a corresponding change in the form of the parasite.

Perhaps the strongest proof that the coccus-like bodies and the pyriform, amœboid bodies are stages of the same parasite was furnished recently in an unexpected manner. Two cows (Nos. 206 and 219) inoculated with blood from healthy North Carolina cattle early in July, 1892, developed the acute type of Texas fever with the appearance of pyriform parasites within the red corpuscles. Both recovered, and the number of corpuscles was rising toward the normal, when, at the end of August, a relapse was detected in both animals. The number of corpuscles was rapidly falling again and many were infected with the coccus-like bodies. Reinfection from without can hardly be considered in these cases, as there were no ticks in the field and two control animals had normal blood throughout the season.*

THE PROBABLE LIFE HISTORY OF THE MICROÖRGANISM IN THE BODY OF CATTLE.

We have thus far presented in a somewhat fragmentary manner the observations bearing upon this microörganism. It now remains to put them together in a way which will illustrate its probable development.

In the early stages of the high fever in a few acute cases, before the destruction of red corpuscles had gone far, very minute bodies were seen in fresh blood. Their form, so far as determinable (apochrom 2 mm., ocular 8) appeared as an elongated figure of eight or two short rods attached end to end. They had a very active Brownian motion in addition to a movement which carried them from one place to another in the field. This latter movement may have been due to currents in the liquid. They could not be detected in preparations stained with methylene blue. That this is the free form which precedes the parasitic stage must remain at present a mere conjecture.

The (hypothetical) swarming or motile stage (intraglobular).—We have

* Since writing this two other cases (Nos. 222 and 230) inoculated in the same manner have passed through a relapse.

already (on p. 56) referred to certain very minute, well-defined, bright, frequently motile, bodies seen within the red corpuscles of healthy cattle at various seasons of the year. As might have been expected, these bodies were found in Texas-fever blood as well. It has also been stated that they vary more or less both in size and form. The question has frequently presented itself, whether some of these bright motile bodies were the progenitors of the coccus-like and the pyriform bodies of the Texas-fever parasite. Inasmuch as they are present both in health and in disease, only a most trying examination of the blood in many cases could decide whether certain forms only appeared in disease or not. These bodies are so minute and so inaccessible that it is by no means certain whether such a prolonged study would bear fruit. In the course of these investigations such a study was impossible, and we have simply to present the facts that these bodies are present in health and disease and that they vary in size and form. In one case it was difficult not to accept the hypothesis that some of the bodies are a stage of the micro-parasite. In No. 56, affected with the mild autumnal disease, these bodies grew in number with the peripheral coccus-like bodies and disappeared at about the same time. This view is presented simply to serve as a working hypothesis for such as are inclined to follow this phase of the subject more minutely. There is nothing in this hypothesis not in harmony with the positive observations concerning the Texas-fever microbe. Such a motile, swarming stage is one which can readily be conceived of as finding its way into the red corpuscle constantly in motion in the vessels of the body. Why it is not seen in every case may be explained by the same hypothesis which accounts for the presence of the peripheral coccus-like stage in the milder type of Texas fever. This hypothesis assumes a retardation in the intraglobular development of the micro-parasite by which the smaller stages remain long enough in the blood to be detected. If the retardation is still more pronounced, it is easy to conceive of the motile or swarming stage as circulating in the blood long enough to be detected.

The stage of the peripheral coccus-like bodies.—After the (hypothetical) swarm-spore has penetrated into the corpuscle it comes to rest, loses its bright, refrangent appearance, and attaches itself near the periphery of the corpuscle as a pale body which is only detected with difficulty in the unstained corpuscle. This body next undergoes division which is probably incomplete, for in the more advanced stages the two resulting bodies are as a rule still attached to each other. These remain close together while the infected corpuscle is circulating in the blood. This stage of the coccus-like body, like the preceding hypothetical stage, must be regarded as recognizable because of a retarded development of the micro-parasite. It is probable that this retardation of development in susceptible animals is due to meteorological conditions, such as low temperature of the air, and to partial immunity. In acute attacks the

enormous multiplication of the parasite in the blood shows how rapid in such cases its development and how ephemeral these intermediate stages must be. The period of retardation may vary in length, but it seems probable that this stage may remain in the circulation at least several days.

The stage of the larger forms (pyriform and spindle-shaped bodies).—The two coccus-like bodies resulting from division begin to grow and assume fusiform outlines. It is probable that they remain attached to each other at least for some time, for in stained preparations a very delicate stained line may occasionally be traced passing from one to the other. In this stage they stain very well in hæmatoxylin and basic aniline dyes. As they continue to enlarge, the two members of the pair remaining always of the same size, a more elongated, pear-shaped outline is assumed, and in the unstained condition a minute dark particle is observed in the broad end of each body. Under conditions not definable a larger or smaller number of the red corpuscles contain but one body. These unpaired forms are found most abundantly in the circulating blood, where they may manifest amœboid changes.

The larger forms circulating in the blood do not stain so well as the somewhat smaller bodies found in the capillaries after death. This may be due to degenerative processes or to a transformation into some unknown reproductive state. The annexed figures illustrate, diagrammatically, the intraglobular stages of the Texas-fever parasite, *i. e.*, those forms which have only been found in the blood during Texas fever, and very rarely in southern cattle.

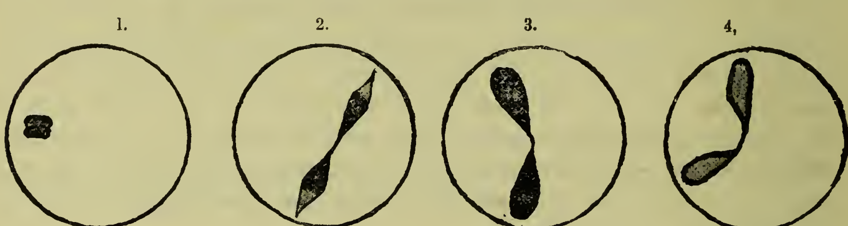

FIG. 3.—Intraglobular forms of the Texas-fever parasite. The shading shows the relative staining capacity with methylene blue. 1. The peripheral coccus-like body (0.6 μ long) in process of division (from the mild type). 2. Larger spindle-shaped forms from the capillary blood of the heart muscle. The free ends are but feebly stained. 3. Larger pyriform bodies from the same source staining entirely. 4. Pyriform bodies (2 μ long, 1.5 μ wide at the widest portion) staining but feebly; from the circulating blood. (The last three forms from the acute type.)

Free bodies.—These are set free after they have reached the preceding stage by the disintegration of the infected corpuscles. They may be found in capillary blood of the heart muscle in abundance. Their most common location is in the kidneys, however.

No forms which might be interpreted as reproductive stages have been recognized at any time in the many cases which have been studied. That the organism multiplies very rapidly in the blood of susceptible cattle is demonstrated by the fact that the injection of a small quantity of infected blood gives rise to the disease. How does this multiplica-

tion take place? There are two possibilities in view. Either the large pyriform body, while within the corpuscle or after it is set free, may enter the reproductive stage and produce a generation of very minute bodies akin to the motile, bright intraglobular bodies seen in fresh blood, or there may be a free reproductive phase, distinct from the intraglobular forms, taking place in the blood.

THE NATURE OF THE TEXAS-FEVER MICROÖRGANISM AND ITS RELATION TO THE PARASITES OF THE RED CORPUSCLES OF OTHER ANIMALS AND OF MAN.

It has been known since 1881 that the various types of malarial fever in man were accompanied by minute organisms living within the red corpuscles. This discovery by Laveran has been followed by confirmations in various parts of the world, and it is generally accepted that these intraglobular organisms are the cause of malaria. Stimulated by this important discovery, various observers have studied the blood of many animals (frog, turtle, and various birds) and have found therein certain minute parasites which likewise pass their life chiefly within red corpuscles. Much has been written upon the interrelation of these forms and their bearing on malaria in man. Nothing positive, however, has come of it, although there is a close resemblance between some of the parasites found in birds and those found in man. They all have in common the peculiar habit of living in the red corpuscles. Those of cold-blooded animals (frog and turtle) do not contain any pigment granules. On the other hand, those of birds and man do, as a rule, contain granules of dark pigment which is derived from that portion of the red corpuscle destroyed by them. These pigment granules are by some regarded as the more abundant the more retarded the growth of the parasite, and consequently the slower the destruction of the containing corpuscle. The parasites found in the blood of birds and man first appear as minute, slowly enlarging amœboid bodies in the red corpuscles. Soon pigment granules appear. When of a certain size these bodies break up within the corpuscles into a variable number of spores. These are set free and begin life as a new generation by entering other red corpuscles and undergoing the same development. These cell parasites are not associated with a visibly diseased state of the animals in which they are found. In man it is well known that certain kinds of fevers known as malarial are produced by them.

The Texas-fever parasite differs in many important respects from all those thus far described. Its morphology is quite unique. It contains no pigment. It probably runs through its whole development in a short time, otherwise it would be difficult to account for the rapid destruction of red corpuscles. Nevertheless, no distinctly reproductive phase has been seen during four years of observation of a great variety of cases.

It is hardly within the scope of this report to go into any details con-

cerning the parasites of the red corpuscles of other animals and of man. The literature of this subject has now grown quite voluminous, although the progress made is not very great, owing to the limitations of methods. None of these cell parasites have thus far been cultivated according to bacteriological methods, and it is not likely that they ever will be. Inoculations of blood containing them seem to succeed only when they are made on the same varieties of the same species of animals, according to Celli and Sanfelice,* and even then success is limited to a small number of the cases inoculated. Observations are thus of necessity statistical and comparative rather than experimental, and must extend over a large number of cases before the significance of the various facts observed can be even formulated. Even then it is difficult to impart to others the conviction which comes from prolonged observation, while the desultory observations of many individuals lead to wide differences of opinion.

Classification of the parasites of red corpuscles has been attempted by Kruse and others and the various forms indicated under the following scheme:†

Genus.	Species.	Variety.
1. *Hæmogregarina* (Danilewsky)	*H. ranarum*, Danil. *H. testudinis*, Danil. *H. lacertæ*, Danil.	
2. *Hæmoproteus* (Kruse)	*H. columbæ*, Grassi. *H. Danilewsky*, Kruse. *H. aluci*, n. sp. *H. bubonis*, n. sp.	
	H. passeris, Grassi	*a.*[1] *c.*
	H. noctuæ, n. sp	*a.* *c.*
	H. alaudæ, n. sp.	*a.* *b.* *c.*
3. *Plasmodium* (Marchiafava et Celli)	*Pl. malariæ*, M. et C.	*a.* Quartanæ. *b.* Tertianæ. *c.* Quotidianæ

[1] The letters refer to the relative rapidity with which the development goes on; *a* signifies slow; *b*, accelerated; *c*, rapid.

It seems improbable that the Texas-fever parasite will ever be ranged under any of these genera, and therefore a new genus has been created for it (*Pyrosoma*). The specific name (*bigeminum*) is derived from the peculiar character which this organism has of appearing in pairs within the red corpuscles. This name does not commit it to any special group of protozoan parasites, although it is not improbable that it may belong to the sporozoa to which most cell parasites belong. The peculiar pair of pyriform bodies within the red corpuscles might be homologized with the falciform bodies or crescents of the sporozoa, which in this case are without a cyst of their own and make use of the cell wall for this purpose.

* Fortschritte der Medicin, 1891. Nos. 12, 13, and 14.

† Loc. cit., No. 14.

The great rapidity with which this parasite multiplies in the system of susceptible cattle may perhaps be explained along lines suggested by R. Pfeiffer* in his observations on *Coccidium oviforme* and *C. perforans* in the rabbit. These two species of sporozoa (the former inhabiting the bile ducts of the adult rabbit, the latter the intestinal epithelium of the young rabbits), Pfeiffer maintains, are one and the same which runs through a rapid entogenic development, with the formation of an immense number of individuals in the intestines of young rabbits, and thereby causes a severe (mostly fatal) disease, while in the adult it remains largely restricted to the liver, where it runs through a slow partial development, and the spore produced requires conditions only found externally for its further development. Applying these observations to the Texas-fever organism, we may assume some dual development of the parasite, one taking place in susceptible, the other in insusceptible animals. Or the conditions may be much simpler in the latter, and depend largely on a simple repression of the multiplication of the parasite in the red corpuscles, owing to some unknown modification of these bodies.

PROBABLE ACTION OF THE MICROÖRGANISM IN THE BODY OF SUSCEPTIBLE ANIMALS.

This topic has been touched upon in the foregoing chapters, but only in a desultory manner, and the known facts are brought together here in a more compact form. The demonstration of the microörganism in the organs does not present any special difficulties. The organs were examined fresh or after being in the ice-chest for twenty-four hours, both in teased preparations and in sections. The teased preparations as well as the sections were examined in iodized serum to avoid any injury to the blood corpuscles. For the same reason the sections were prepared with the razor and not on the freezing microtome. In such thin sections or in teased preparations some of the capillaries frequently remained intact and the microörganisms could be made out as pale, roundish dots within the red corpuscles. Plate VII, Fig. 3, is drawn from an unstained teased preparation of the fresh spleen. Tissues were hardened both in strong alcohol and in Müller's fluid and alcohol, according to the usual procedure. The staining presented some difficulties, and in general the aniline dyes did not give satisfactory results. Hæmatoxylin in the form of Ehrlich's acid hæmatoxylin has proved very satisfactory in bringing out the intraglobular parasites. In tissue hardened in Müller's fluid the outer layers showed a peculiar modification of the parasites. Instead of appearing as blue bodies, they assumed a brownish-red color. This was especially noticeable in tissues which are very delicate, such as the choroid plexus. In these all the parasites appeared brownish red instead of blue. This may be due to the action of the

* Beiträge zur Protozoen-Forschung. I. Heft.

Müller's fluid. Tissue hardened in alcohol, while it demonstrates the intraglobular bodies very distinctly, does not preserve the corpuscles so well.

The destruction of red corpuscles by the micro-parasite within them is the main fact in the pathology of Texas fever. There are, however, some secondary phenomena associated with this destruction which account in part, at least, for the peculiar lesions of this disease. The infected corpuscle remains in the circulation as long as the contained parasite is below a certain size. Thus, in the mild autumnal form of the disease, the number of circulating corpuscles invaded by the coccus-like bodies is rarely below 5 per cent, commonly from 10 to 30 per cent, and at times near 50 per cent. The corpuscles are not changed in form or size, and in fact the parasites are very small when compared with the size of the corpuscle and only brought out distinctly by staining. When the parasite has reached a certain size we may assume that the corpuscles lose their flexibility and adaptability to the minute channels or capillaries and become lodged in them, forming emboli, so to speak. The capillary becomes obstructed and red corpuscles are wedged in behind the infected ones. It is highly probable that at this time a favorable opportunity is offered to the free, earliest stage of the micro-organism to attack the remaining corpuscles, otherwise it would be difficult to understand why capillaries are frequently found which contain, to all appearances, only infected corpuscles. It may be that other factors come into play, such as the changed specific gravity of the infected corpuscles, by which their relation to the blood plasma becomes changed and in virtue of which they act as foreign bodies in the vessels. Whatever may be the reason, the fact remains that the paucity of infected corpuscles in the blood taken from the large vessels and the heart is counterbalanced by a very extensive infection of the corpuscles found in the capillaries. The smaller the capillary, the higher the percentage of infected corpuscles. In the white substance of the brain, in No. 198, for instance, the capillaries in a section were found completely filled with red corpuscles and every corpuscle was infected. Similarly, capillaries have been observed both in sections of hardened tissue and in teased preparations of fresh tissue from the spleen, kidneys, intestinal mucosa, omentum, plexuses of the brain, heart muscle, and red marrow of the ribs, which were either completely or partly filled with infected corpuscles alone.

This capillary plugging or embolism may account, to some extent at least, for the enormous distention of the spleen and for the degenerative changes of the parenchyma of the liver. The perinephritic sanguinolent œdema so frequently observed on post-mortem examination is probably due to the complete filling up of the vascular system of the kidneys with infected and uninfected corpuscles. Similarly the ecchymoses in the calyces of the pelvis may be accounted for by this condition.

Another phenomenon of interest is the remarkable injection of all pathological growths of a vascular character, such as old fibrous adhesions and pleuritic fringes. Similarly vascular fringes found on the omentum covering the paunch, and on the origin of the large vessels at the base of the heart appear as dark-red spots. Here microscopic examination shows the same abundant infection. The intense injection of the vascular plexuses of the brain cavities is associated with extensive infection within the capillary network. This injection of the entire capillary system of the body may be largely aided by the presumable rise of blood pressure which must take place after the enlargement of the liver and the engorgement of the spleen and kidneys practically shut these organs out of the general circulation.

While the skeletal muscles show but slight infection, the heart muscle is severely involved. Probably owing to the smaller caliber of its capillaries and the constant contraction of the muscular walls, a favorable opportunity for the lodgment of infected corpuscles is afforded. In the capillaries of the heart muscle the infection of corpuscles is always very great and freed forms of the parasite are abundant. The capillary plugging will account for the almost constant ecchymoses of the external and internal surfaces of the ventricular walls.

The breaking up of the infected corpuscles probably takes place in the capillaries over the entire body, for, as stated above, freed parasites are found in the capillaries of the myocardium after a certain period of fever. This leads to the presence of free hæmoglobin in the blood (hæmoglobinæmia). This condition was strikingly demonstrated in the case of a fœtus about three months old taken from a cow which had succumbed in the acute stage. The amniotic fluid had a beautiful wine-red color. It is probable that many infected corpuscles which break away from the capillary plugs are carried into the kidneys, where the final dissolution takes place. Otherwise it would be difficult to account for the usually enormous numbers of free as well as intraglobular parasites which are found in the kidneys toward the end of the fever.

The hæmoglobinuria observed in nearly all acute cases may be due in part to a transudation of the hæmoglobin dissolved in the blood, in part to the destruction of red corpuscles in the kidney itself. The same may perhaps be true of the material transformed into bile by the liver. This organ is as a rule heavily infected, though not to the extent observed in the kidneys. The bile contains to all appearances a very large quantity of bile pigment. This may be derived in part from the dissolved hæmoglobin in the general circulation and in part from the corpuscles undergoing destruction in the capillaries of the liver itself.

The cause of the high temperature in the later stages of the fever, when the pathological changes are well under way and when the blood is loaded with the débris of corpuscles and free parasites, may not be open to discussion. In the earliest stages, however, the explanation of

waste products in the blood does not seem to follow in every case. In a few the fever was high, although there was no apparent reduction of red corpuscles. (See Nos. 166, 180, 198, 206, 219.) It must be stated that in view of the fluctuations to which the number of corpuscles is subject the counts in these cases may be somewhat misleading. Yet on the whole the initial fever seems to be caused by something other than the destruction of the red corpuscles, and we may invoke two possible causes, leaving their determination to more accurate continued observations on single cases. These are the multiplication of the parasite in the blood, perhaps independent of the corpuscles and the thrombosis of capillaries in the nerve centers.

The question of a cyclical destruction of red corpuscles corresponding to the different generations of parasites is an interesting one, but the observations put on record in the appendix do not give us any definite information. In acute cases after the first few days the fever is continuous or nearly so and does not indicate any intermission or remission of the acting cause. Whether the individual generations follow one another so rapidly or whether there are a number of generations intermingled has not been determined. To the eye there is more or less uniformity in the size of the parasites observed in any given case throughout the body. They may be all minute in the stage of the coccus-like bodies or they may all be unusually large (No. 66) or they may all be in a stage intermediate between these extremes. It should be stated, however, that in a few cases the fluctuation in the destruction of the red corpuscles was regular enough to suggest a period of from one and a half to two weeks in such cases. (Page 40.)

What becomes of the micro-parasites in those cases which recover? We have already signalized the setting free of the parasites and their accumulation in large numbers in the kidneys. Further than this the observations do not go. The parasites are perhaps destroyed by a combination of circumstances, one of which is the small number of red corpuscles finally left for infection. Thus in blood containing only one and a half to two million red corpucles fully one-half are enlarged, embryonic forms which may not be so well fitted for the growth of the parasite. Another circumstance may be the unfit condition of the blood due to the presence of the very débris which the parasites have aided in producing.

OUTBREAKS IN WHICH THE TEXAS-FEVER PARASITE HAS BEEN DEMONSTRATED.

The parasite of Texas fever, or more particularly the coccus-like and the larger pyriform stage of this microörganism, have been demonstrated in the following outbreaks:

(1) In the spleen of a case from an outbreak in Virginia, September, 1886.

(2) In the organs of cases from an outbreak in Maryland, September, 1888.

(3) In the blood and the organs of cases from an outbreak on the experiment station (North Carolina infection), August to October, 1889.

(4) In the blood and the organs of cases from an outbreak on the experiment station (North Carolina infection), September to November, 1889.

(5) In the blood and the organs of cases from an outbreak on the experiment station (North Carolina infection), August to November, 1890.

(6) In the blood and the organs of cases from an outbreak on the experiment station (Texas infection), August to October, 1890.

(7) In the spleen of a case which died in North Carolina, June 29, 1891.

(8) In the blood and the organs of cases from an outbreak on the experiment station (North Carolina infection), August to November, 1891.

(9) In the blood of a case from an outbreak in Pennsylvania, November, 1891. (Specimens of organs and urine sent by George Jobson, jr., v. s.)

(10) In the organs of a case at Fort Smith, Ark., March, 1892. (Preparations sent by R. R. Dinwiddie, v. s.)

(11) In the organs of a case produced by the intravenous inoculation of blood from North Carolina cattle, July, 1892.

(12) In the organs of cases from an outbreak produced at the experiment station in the usual way by North Carolina cattle, August and September, 1892.

(13) In the organs of cases from an outbreak in New Jersey, August, 1892.

(14) In the spleen and blood of cases from an outbreak at Camden, N. J., August 1892. (Specimens sent by Drs. Miller and Sellers.)

In Nos. 7 and 13 there were the usual lesions (hæmoglobinuria, etc.,) observed by Dr. F. L. Kilborne at the autopsies. In No. 9 there were the usual fatty degeneration and bile injection of the liver and hæmoglobinuria. The diagnosis of Texas fever was thus assured in all the outbreaks mentioned.

THE PRODUCTION OF TEXAS FEVER IN CATTLE BY THE INOCULATION OF BLOOD FROM CASES OF THIS DISEASE.

The demonstration that Texas fever is caused by a certain microörganism is not absolutely made by showing that it is always associated with this disease and not observed in health. It may be argued that such bodies are the concomitant rather than the cause of the fever. Nevertheless it may be said that no microörganism constantly associated with a given infectious disease has yet been found which is not demonstrably or presumptively the cause of the disease. Hence the probability that the micro-parasite described is the cause of Texas fever is very high, although the demonstration can not be made until such organism can be cultivated in some manner outside of the animal body and inoculations made with pure cultures. There is nothing to-day to encourage us in the hope that parasites so highly adapted as the one under consideration will ever submit to the crude culture methods successful with many bacteria.

The high probability that we have the cause of Texas fever before us is increased by the fact that when blood from cases of this disease is injected into the circulation of healthy susceptible cattle, the disease is produced and the micro-parasite appears in the blood under the same conditions under which it becomes manifest in the natural disease. There is still the possibility before us that the microparasite is transmitted in the diseased blood and that some unknown agent has been

transmitted with it which is the true cause of the infection. It is useless to discuss this further, and each reader must form his own opinion of the value of the experimental evidence adduced in this report.

Before quoting our experiments in the production of the disease, a few observations on the attempt of others to produce it are in order.

Dr. D. E. Salmon in 1880 (4, p. 303), made a number of inoculations with tissues and fluids taken from cases of Texas fever, some of which were successful:

(1) November 7, 1879. Calf 6 to 8 months old inoculated subcutaneously with bile and blood kept ten days in a sealed pipette. No result.

(2) September 14, 1881. Yearling inoculated subcutaneously with 5 cm^3 blood from a case dead three or four hours. No result.

(3) September 29. Yearling bull inoculated subcutaneously with 5 cm^3 blood containing some spleen pulp, which had been kept twenty-two hours in sealed pipette.

(4) Red cow inoculated as No. 3; also drenched with a mixture of blood, urine, and bile.

(5) Heifer received a subcutaneous injection of 5 cm^3 of bile.

(6) Bull 3 years old drenched with one ounce of urine.

(7) Steer 2 years old drenched with one ounce of bile.

(8) Cow received 5 cm^3 of urine under the skin.

Of the cases from Nos. 3 to 6, inclusive, No. 3 and No. 4 reacted with a high temperature and No. 4 became very weak and emaciated. In 1883 (5, p. 34) three additional experiments are reported. A steer and a heifer, 2½ years old, received August 7 subcutaneous injections of spleen pulp suspended in water. The spleen pulp had been kept in a sealed tube for seven days. Neither animal became affected. A third animal, a cow which had been inoculated subcutaneously with fresh splenic pulp, October 3, was taken sick in ten days and died three days thereafter. There were evidences of hæmoglobinuria. Two young animals drenched with the same splenic pulp did not become seriously affected.

A number of additional inoculations were made with cultures of a micrococcus cultivated from the spleen of a case of Texas fever with negative results in all cases.

Dr. Billings gives the notes of a case inoculated with cultures of what he regards as the Texas fever bacterium (8, p. 100). We have already commented on this case on p. 52. In this connection it is sufficient to say that the proof of Texas fever has not been brought in this case although it should have been above reproach since it is supposed to establish the etiology of Texas fever. The observations in this report show that there is no Texas fever without a marked reduction in the number of red corpuscles. This is the essential sign of Texas fever. Secondary to this are lesions of liver, spleen, and kidneys, and hæmoglobinuria and the presence of embryonic corpuscles in the blood. There is nothing in the autopsy notes as published by Billings to demonstrate the presence of Texas fever in the absence of red water. It is also curious that in his experiment the young animal of 5 months should take the disease more severely than the "large red cow," since calves are proverbially resistant.

In the report of Paul Paquin (9, p. 46) we find the following statements:

Texas fever is transmissible not only from Southern stock to susceptible Northern cattle, but under favorable circumstances is inoculable *between Northern natives*, although in the ordinary course of things in our climate transmission does not occur. We have inoculated native Missouri cattle with spleen and liver pulp from *other diseased natives* and produced typical cases of Texas fever, but it took large doses of virus. The rapidity of the course of the malady depends much on the origin and age of the virus. It was more rapid from old pulp kept in warmth and properly preserved than it was from virus of fresh matter, and it seems impossible to cause severe *Texas* fever with *fresh* urine, whilst the same exposed to warmth awhile becomes dangerous.

There are no experiments reported to convince the reader of the truth of these statements, though the direct transmission of disease from Southern cattle and sick natives to susceptible cattle by inoculation has been confirmed by us. Why old spleen pulp and old urine should be more dangerous, excepting as producers of septic conditions, is by no means clear. We should believe the contrary. We have no information at all as to how the inoculation was made or any to show that the inoculated animals did contract Texas fever excepting the bare statement that the inoculations were successful.

R. R. Dinwiddie (10) made subcutaneous inoculations upon four different animals with fluids and tissues from cases of Texas fever. We are glad to see the experiments reported so that they may be estimated at their true value. The inoculations were made with fresh urine, spleen pulp kept over night, with bile kept in a sealed pipette, and with a culture of a micrococcus from the liver of a case of Texas fever. These inoculations proved negative. A fifth animal which received spleen pulp kept over night as a drench remained well. We have no reason to doubt the accuracy of these results. The negative outcome may have been due to the fact that only young animals were used and that the season was perhaps too advanced for experimental cases to succeed.

In all of these experiments the uncertainty of the conclusions reached as regards the negative results must be evident to all who have read the foregoing part of this report. Many of the cases, which to all appearances were not affected, may have passed through a mild attack, recognizable only by the microscopic examination of the blood corpuscles and a determination of their number.

Our own experiments were made mainly with fresh material, and this was injected under the skin and into the blood directly. Nine inoculations were made in all.* We shall in this place only refer to the important points in each case, and leave the reader to consult the appendix for fuller details.

(1) On September 1, 1890, No. 111, a heifer about 21 months old, received into one of the jugular veins 13 cc. of whipped blood. This was

* Five additional cases of Texas fever were produced with the blood of healthy North Carolina cattle (page 119).

obtained from No. 128, which had just died, and in whose blood there was a large number of infected corpuscles. The defibrinated blood was kept in a warm chamber at 35° C. for three hours before the injection. An examination of the table in the appendix shows a decided fall in the number of red corpuscles on the thirteenth day, and several days thereafter a considerable number of new red corpuscles (macrocytes) were found in the blood. There can be no doubt that this was a mild case of Texas fever. The subsequent gradual weakening of this animal and death 3 months after the inoculation could not be accounted for.

(2) On September 16, 1890, a similar injection with defibrinated blood was made on No. 142. The blood was taken from the heart of No. 90 about one-half hour after death, and, after defibrinating, it was kept at 35°–40° C. for one and one-half hours before it was injected. In the table we observe a marked fall in the number of red corpuscles at three different times from two to three weeks apart*. The animal fully recovered subsequently. Neither of these cases would probably be considered conclusive evidence that the disease can be reproduced in this way. The seven following cases will dispel any doubt on this point.

(3) On September 19, 1891, a portion of the heart muscle of No. 181, just dead, was pounded in a mortar with sterile normal salt solution. The resulting reddish fluid was filtered and injected into the jugular vein of No. 182, after standing in a warm chamber for about one hour. The table in the appendix with this case leaves no doubt as to the nature of the disease. The temperature (see appendix) rose on the sixth day in the evening and a high evening temperature was observed for ten days thereafter. A high morning temperature was first noted on the eighth day and the fever remained continuously high for at least four days thereafter. The number of blood corpuscles had fallen from 6,000,000 to 2,000,000 eleven days after the inoculation. The Texas-fever parasites were found in the blood. The animal fully recovered subsequently.

(4) On the same day blood was withdrawn from the jugular vein of No. 181, then still alive, and injected at once into the jugular of No. 185. The whole operation lasted one or two minutes. Of this blood, which contained at the time perhaps one-half to one per cent infected corpuscles, two syringefuls, or 28 cc., were injected. The disease produced in this animal was severe enough to leave no doubt as to its nature. The evening temperature was high on the third day and was low again on the ninth day. The continuous high temperature lasted four days. The number of blood corpuscles had fallen from 5,000,000 to 2,000,000 on the tenth day. The Texas-fever parasites were found in the blood. The animal fully recovered subsequently.

(5) No. 186 was treated precisely as No. 185 at the same time. A

*See appendix for record of control animal No. 143 in the same inclosure.

very severe case of Texas fever was the result. The temperature and the loss of red blood corpuscles were the same as in No. 185 (see page 17 for curve). On the ninth day she could scarcely stand and was trembling and quivering over the whole body. A syringeful of blood was withdrawn at the time from a jugular vein for other inoculations, and the operation was followed at once by convulsions and death. The very advanced lesions of the liver and spleen, the dark red, port-wine-colored urine, and the immense number of infected corpuscles in the various organs, made this case one of the most severe of the season.

In 1892 four cows were inoculated with blood obtained from a case of the disease. All became affected within a week and three died. The more important facts in connection with these inoculations are reproduced here.

On August 27 blood was withdrawn from the left jugular vein of No. 222, then suffering with the disease. In the blood a small number of large intraglobular parasites were found. The skin over the jugular was shaved and washed with .1 per cent mercuric chloride and the vein opened with a scalpel. The blood was caught in sterilized bottles, containing glass beads, and defibrinated by shaking vigorously for ten minutes. The bottles were kept in a water bath at 40°–42° C. The injections were performed not longer than fifteen to twenty min-minutes after the withdrawal of the blood from No. 222.

(6) No. 197, a cow 6 years old, received into the left jugular 14 cc. (one syringeful) of this blood.

(7) No. 227, a cow 11 years old, received under the skin of the neck ½ cc. of the same blood in four different places, *i. e.*, 2 cc. in all.

(8) No. 228, a cow 7 years old, received subcutaneously ½ cc. in two places, *i. e.*, 1 cc. in all.

No. 197 died quite unexpectedly September 4, eight days after the inoculation. The temperature had been high since August 31. The autopsy left no doubt as to the nature of the disease.

No. 227 died September 9, thirteen days after the inoculation. The temperature had risen and other symptoms of disease had appeared September 2. On the day of death the red corpuscles had fallen to 1.5 million. The autopsy revealed the usual lesions of Texas fever in a very marked degree. The urine was visibly free from hæmoglobin. The small number of red corpuscles just before death indicated that the period of hæmoglobinuria was past.

No. 228, which had received the smallest dose, reacted as promptly as the foregoing with a high temperature. The usual symptoms appeared, but more tardily, and the animal finally recovered. On September 14 the red corpuscles numbered 1.5 million. From this time there was slow improvement in the condition of the blood.

(9) One bottle of the defibrinated blood with which the preceding animals had been inoculated was placed in a refrigerator at an average

temperature of 50° F. (10° C.) from August 27 until August 30. On this day 14 cc. (one syringeful) was injected into the left jugular vein of No. 200, a cow 8 years old. After five days of elevated evening temperature and two of continuous high temperature, this animal succumbed September 8. The organs presented the usual lesions of Texas fever. The urine had a dark port-wine color. In the various organs and the blood many infected corpuscles were detected.

With these positive results before us we need not hesitate to make the statement that there is something in the blood of cattle during Texas fever which, introduced into the body of healthy susceptible cattle, gives rise to the disease. This something is capable of reproducing itself indefinitely in the blood of susceptible animals. In all cases there had been multiplication of the Texas-fever parasite, and these inoculations furnish additional proof that this parasite may be regarded as the cause. These inoculations show, also, that a comparatively small quantity of blood from diseased cattle placed under the skin is capable of causing a severe and even fatal infection. In this respect the microörganism seems to have as powerful an effect as the bacteria which produce acute fatal forms of septicæmia and seems to be capable of almost equally rapid multiplication. The sojourn of three days in a refrigerator did not destroy the vitality of the microörganism as it exists in the blood. The very severe inoculation disease produced in 1891 and 1892, as compared with 1890, is partly to be accounted for by the fact that only old animals were used latterly, while in 1890 the animals were young. The observations made in the field experiments and by former observers, that the susceptibility seems to increase with age, provided there has been no exposure to the disease at any time in life before, is thus indirectly confirmed by inoculation. The very striking susceptibility of cattle to this disease was furthermore demonstrated by the intravenous inoculation of three guinea-pigs at the same time with three of the cases cited above (Nos. 6–8, inclusive). These animals remained perfectly well, though they had received relatively to their body weight a very much larger quantity of the defibrinated blood. (Page 84.)

THE INOCULATION OF ANIMALS OTHER THAN CATTLE WITH TEXAS-FEVER BLOOD.

The inoculation of animals other than cattle had a twofold purpose: first, to determine whether other domesticated animals are likely to become infected with the micro-parasite and perhaps cause the dissemination of Texas fever, and, second, to find some small animal to take the place of the much more costly cattle in the study of the parasite and the disease. This was especially desirable since this parasite can not be cultivated outside of the animal body.

Sheep.—Since sheep and cattle are so closely related it was thought that the disease might perhaps be induced in them. For this purpose

a lamb was used. A syringeful (7 cc.) of blood was drawn from the right jugular of cow No. 184, which was very sick at the time and whose blood contained the micro-parasite in small numbers, and injected at once into the left jugular vein of the lamb. The operation was performed October 1, 1891; the blood contained 10,442,000 red corpuscles in a cubic millimeter. No parasites of any kind were detected in them.

October 13.—Red corpuscles 8,282,000. Nothing abnormal detected.

October 27.—Red corpuscles 11,538,000. Several bright intraglobular bodies seen in the fresh preparation, but no parasites.

From October 1 to October 27 the temperature was taken twice daily. It fluctuated between 101 and 103.

Though the inoculation was made somewhat late in the season the outcome plainly indicates no susceptibility of sheep to this disease.

Rabbits.—September 20, 1889, immediately after cow No. 54 had been killed a quantity of spleen pulp containing many corpuscles infected with large paired parasites was mixed with sterile salt solution. The reddish liquid was injected into the ear vein of three rabbits. No rise of temperature and no symptoms of disease were noticed. One rabbit was killed on the seventh day and the blood and organs carefully examined for infected corpuscles with negative result. The others were watched for several months, but nothing abnormal detected in their action. The second rabbit, which had become scabby, was killed January 18, 1892. The various organs and the blood were examined microscopically with negative result. The following may also be cited:

October 1, 1891.—With the blood of cow No. 184 two rabbits (Nos. 140, 141) were inoculated at the same time with the lamb. Each received 1 cubic centimeter into the ear vein.

No. 140 (black rabbit) showed no external symptoms of disease. The blood was examined twice and no infected corpuscles found.

October 19, 1891, 6,537,000 red corpuscles in a cmm.

December 3, 1891, 7,134,613 red corpuscles in a cmm.

No. 141 (white rabbit) remained equally well. The following blood examinations were made:

October 19, 1891, 5,268,000 red corpuscles in a cmm.

December 3, 1891, 4,533,000 red corpuscles in a cmm. Infected corpuscles absent.

Pigeons.—September 28, 1891. Blood containing infected corpuscles is drawn from the jugular vein of cow No. 186 and injected at once into the wing vein of three pigeons (Nos. 2, 3, and 4). In a fourth pigeon (No. 1) the blood failed to enter the vein and was deposited in the surrounding connective tissue, Each received about 1 cc.

No. 1 died October 13, though not from the inoculation, as its feathers were ruffled at the time of the operation and it was probably not well at that time. Examination of the blood and organs negative. The other pigeons remained well, On October 5 the blood of No. 3 contained 3,926,800, that of No. 4, 4,094,300, red corpuscles, in a cubic millimeter. They were killed January 22, 1892. The blood of No. 3 was searched in vain for parasites.

Guinea-pigs.—August 27, 1892. Blood was drawn from the left jugular of cow No. 222 affected with Texas fever into sterile wide-mouthed bottles containing glass beads and defibrinated by shaking vigorously. Three guinea-pigs were inoculated: No. 1 received into the exposed jugular 1 cc. of defibrinated blood; No. 2 received into an ear vein ½ cc.; No. 3 received into an ear vein 1 cc.

The injections were completed fifty to seventy minutes after the blood had been drawn from No. 222. The injection into the ear vein was a perfect success in the two cases on which it was tried. These guinea-pigs remained entirely well. The blood was examined from time to time both in fresh and in dried and stained preparations, but the corpuscles were not counted, owing to the pressure of other work. There was no evidence, however, from the microscopic examination of any change from the normal condition or of any infection. The guinea-pigs were watched for more than a month after the inoculation.

Strongly contrasting with the result on guinea-pigs is that obtained with the same blood on cows. (See page 82 and Nos. 197, 200, 227, and 228.) The largest quantity injected into the circulation of the guinea-pigs was relatively to the body weight not less than twenty-five times greater than the largest dose and three hundred times greater than the smallest dose injected into the cattle. Yet all four cows contracted Texas fever and three died.

Of other observers who have tried to produce Texas fever in other animals we find Paquin (9, p. 46) making the following statement: "We have succeeded also, though with great difficulty, to induce the disease in sheep, guinea-pigs, white mice, white rats, and very rarely rabbits, kittens, and swine. The germs may be reproduced by inoculation of liver and spleen pulp in any of these subjects, but the quantity must be large and the gross typical spleen lesions are not always to be found." Inasmuch as spleen lesions are associated with a variety of infectious and septic diseases in animals, and as there is no record of other lesions peculiar to Texas fever in these inoculated animals, we are compelled to call in question the accuracy of the diagnosis in these cases.

The inoculations made by us demonstrate that sheep, pigeons, rabbits, and guinea-pigs are to all appearances insusceptible to this disease, whereas in cattle the disease may be invariably produced by the injection of infected blood. It is to be hoped that opportunity will be presented the coming summer to try other species of animals.

THE TRANSMISSION OF TEXAS FEVER BY MEANS OF THE CATTLE TICK.

Boöphilus bovis (Riley) Curtice.

It has been a more or less prevalent theory of cattle-owners in the districts occasionally invaded by Texas fever from the South that ticks are the cause of the disease. Mr. J. R. Dodge, (2) in his historical report of this plague, mentions the fact that in 1869 an outbreak in Chester County, Pa., was believed to be caused by ticks. Gamgee in 1868 (2) states: "The tick theory has acquired quite a renown during the past summer, but a little thought should have satisfied any one of the absurdity of the idea." The officers of the Metropolitan Board (1, p. 1084) and most subsequent observers seem to have entertained the same view of the harmlessness of the cattle tick as a carrier of the infection. In fact few observers have given it any thought. In the entire report of F. S. Billings we find no reference whatever to these pests. Paquin (9, p. 45) states that he has "found the parasites also in *ticks bloated with blood of infectious southern cattle.* So this must be added to the list of sources." But the ubiquity of this "germ" rather predisposes one against any belief in its existence if we did not have sufficient positive evidence that bacteria have nothing to do with the disease. The statement thus depends simply upon the finding of a "germ" in adult ticks resembling that found in diseased cattle and in fact everywhere else (waters, soil, manures from the South, urine, bile, liver, spleen, kidneys, etc., of infectious Northern stock). Experiments to demonstrate the relation which ticks bear to Texas fever were not made.

Nothing positive was thus contributed to the elucidation of the action of ticks in carrying the disease until the subject was taken up at the Experiment Station of the Bureau near Washington, in 1889. Here it was found by experiments to be detailed in the remainder of this report that the disease can be produced by ticks hatched artificially in the laboratory, without the presence of southern cattle. Before giving in detail the experiments which led up to the final determination of this important discovery a few facts concerning the cattle tick which have come under our observation are necessary for the information of the general reader. We do not propose to give anything more than a general account of the tick, leaving problems of biology and morphology to those pursuing special lines of work in this field.

THE CATTLE TICK (*Boöphilus bovis*).

Plate X.

The first description of this parasite was made by Prof C. V. Riley, in 1868, under the name *Ixodes bovis* (2, p. 118):

Ixodes bovis Riley.—A reddish, coriaceous flattened species with the body oblong-oval, contracted just behind the middle, and with two longitudinal impressions above this contraction, and three below it more especially visible in the dried specimen. Head short and broad, not spined behind, with two deep, round pits. Palpi and beak together unusually short, the palpi being slender. Labium short and broad, densely spined beneath. Mandibles smooth above with terminal hooks. Thoracic shield distinct, one-third longer than wide, smooth and polished; convex, with the lyrate medial convexity very distinct. Legs long and slender, pale testaceous red; coxæ not spined. Length of body 0.15 of an inch; width 0.09 of an inch.*

The generally accepted idea as to the harmlessness of this parasite caused it to be neglected as an object of study until 1889, when our preliminary experiments seemed to indicate that ticks must be present to convey the infection from southern to northern stock. Hence, Dr. Cooper Curtice, at that time in charge of the investigation of animal parasites, began the study of the life history of this species.† It was discovered quite accidentally that adult females kept confined in bottles or other glass receptacles always lay their eggs. Such a stock of eggs furnished the starting point of Dr. Curtice's investigations. The eggs were placed in covered glass dishes containing a little soil and kept in a warm place. After a period of three to four weeks the young ticks appeared. These were placed on a calf kept in an artificially heated stable, as the season was already advanced (November 15). The earliest or larval stage as it emerged from the ovum had three pairs of legs. After one week's sojourn on the calf it was ready to moult. The emerging nymphal stage was provided with an additional pair of legs. After another week's life on the calf the tick was ready to moult a second time and become sexually mature. Curtice thus showed that in this particular species there are two periods of moulting before the parasite becames matured. He likewise created for it a new genus (*Boöphilus*). Dr. George Marx has given more or less attention to the classification of ticks, and places the species under consideration as follows‡: Class, *Arachnida;* order, *Acari;* suborder, *Cynorhæsta;* family, *Rhipistomidæ*; genus, *Boöphilus*; species, *bovis.*

In our experiments with this cattle tick we have confirmed and extended the observations recorded above chiefly in the direction of the life history, since this is the most important aspect in its relation to Texas fever.

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* We simply quote this description here as a matter of historical interest, without comment as to its accuracy. We may state, however, that the color of adult females is not reddish. The back is olive brown, the belly slate colored. The dimensions given in this diagnosis probably belong to an adult male. For the dimensions of the parasite in its different stages, see this chapter.

† The biology of the cattle tick. Journ. of Comp. Medicine and Veterinary Archives. July, 1891, and January, 1892.

‡ Proc. Entomological Society of Washington, II, p. 232.

The laying of the eggs may be observed by anyone by simply placing full-grown ticks in some vessel from which they can not escape. The tick remains quiet for from two to four and one-half days, according to our observations; then a few eggs will be observed on the mouth parts, which gradually increase in number. The period of oviposition varies somewhat. Confined in bottles, for instance, at a temperature of 68°–78° F. the laying was observed to continue from eight to fifteen days in a lot of 23 mature ticks, each one of which was kept in a separate bottle. The number of eggs varies in general with the length of the egg-laying period. Those which took the longest time laid the largest number. Of four large ticks laying from twelve to sixteen days, each averaged 118 mgr. ($1\frac{13}{16}$ grains) of eggs. Careful counting gave an average of 1,300 eggs per grain. If we take the actual weight of all the eggs laid by the twenty-three ticks, which is 2.41 grams ($37\frac{1}{5}$ grains), a single full-grown tick averages about 2,100 eggs. Ticks do not need to be fully gorged with blood before they are capable of laying eggs. Even such as are half-grown will begin to lay after a few days, but the number is much less than that laid by the large, gorged individuals. Tests showed that 40 half-grown ticks laid no more eggs than would have been laid by seven or eight full-grown individuals. During the process of oviposition the female slowly shrinks in size and when it is completed she appears shriveled and not more than one-half or one-third her former size. The eggs appear as dark, brownish-red masses of oval bodies. The color varies somewhat and its depth appears to be connected somehow with the quantity of blood with which the female is gorged before oviposition. Measurements of freshly laid ova in 1889 made the long diameter 0.519 mm., the transverse 0.38 mm. Measurements in 1892 gave nearly the same figures, 0.496 and 0.384 mm. They are thus, roughly speaking, one-fiftieth of an inch long and one-sixty-sixth of an inch broad at their widest portion.

When masses of ova are placed in glass dishes with a little soil or some leaves and a few drops of water, and the dishes kept closed with glass covers so that the emerging young may not escape, the incubation goes on without any difficulty. The period required for the young to emerge from the shell varies very markedly with the surrounding temperature. In Curtice's first experiment it required from three to four weeks. The temperature of the bacteriological culture room where they were kept could not have been lower than 70° to 80° F. at that time. This relation to temperature is well exemplified in the following experiments:

(1) Ticks sent from North Carolina and received here July 29, 1890, have laid a considerable number of eggs on the way. These are placed in glass dishes and kept in the laboratory. Many young ticks moving about on August 13. Here the period of incubation was from fifteen to eighteen days. The weather during this time was very hot.

(2) Eggs two to three days old placed in glass dishes August 8. Young ticks appeared August 29. Period about twenty-four days.

(3) Eggs several days old placed in dishes August 13, 1890. Young ticks appear in large numbers September 4 and 5. Period approximately twenty-five days.

(4) On September 17, 1890, eggs two to three days old placed in glass dishes. Young ticks first appear October 24, and their number increases until October 28. Period about forty days.

(5) Eggs one to three days old are placed in glass dishes September 20, 1890. Young ticks present in abundance November 1. Period about forty-three days.

(6) Eggs one to three days old are placed in glass dishes September 23, 1890. Young ticks begin to appear November 1. Period about forty days. The eggs from experiments 4, 5, and 6 were taken successively from the same adult ticks. The temperature of the laboratory at this time was 75°–80° F. during the day, but fell 5° or 10° at night.

(7) Eggs one to two days old placed in dishes October 6 and 9, respectively. The dishes were kept on shelves several feet above a steam heater. On November 9 all eggs were found hatched out. Period about thirty days or less.

(8) Eggs two to four days old placed in dishes October 9, 1890. Over steam register only a part of the time. A few young ticks appeared November 15. Hatching completed November 17. Period about thirty-eight to forty days.

From these recorded dates it will be seen how essential a high temperature is for the rapid development of the embryo in the egg. The period of development may vary from fifteen days to six or seven weeks, and may perhaps be prolonged still more by lower temperature. It is evident, however, that a certain temperature level exists below which no development takes place. In the experiments above described there was considerable daily fluctuation in the temperature, and hence they can be made to show only the general relation subsisting between heat and development. To find the lowest temperature at which development may go on would require thermostats in which a certain low temperature could be constantly maintained. It is probable that the shortest period of incubation might be shortened still more by placing the eggs in continuous high temperatures. We have considered this matter more in detail owing to the intimate relation between the period of development of the young tick and the so-called "period of incubation" of Texas fever.

There are some changes which the ova undergo during development which are visible to the naked eye. After a variable number of days each ovum presents a white spot. Under the microscope this corresponds to the position of the cloacal opening, and is nothing else than a mass of white powder composed of very minute spherical crystals. It is an excretory product (urates?) of the young tick, the outlines of whose body and limbs are now visible through the shell under a low power of the miscroscope. The color of the egg itself becomes lighter, and of a more opaque, milky character. Towards the end of the period of development it assumes a peculiar metallic luster. These changes are all caused by the changes going on within the shell.

The minute six-legged ticks (Plate x, Fig. 3) after emerging from the shell are at first of a pale brownish, translucent, waxy color, which soon changes into an opaque brownish hue. They are about 0.67 mm.

(.0268 inch) in length, including the mouth parts. They move actively about, carrying in their cloacal opening the chalky mass of urates (?) mentioned above. They collect along the edge between dish and cover, and scatter as soon as the cover is removed. When confined for some time in the dish, this becomes soiled with a large number of white dots discharged by the ticks.

These minute creatures are very tenacious of life when kept confined in glass dishes containing a little loam or some leaves. Young ticks hatched about the middle of December, 1890, were confined in the same glass dish in the laboratory during the winter. On May 1, 1891, four and a half months after hatching, they were still active. On May 19 a few were still active; some were inert, but not yet dead. Young ticks hatched about July 20, 1891, were still active August 29. The parasitic habit of the tick is probably so complete that no growth and no further development takes place unless the larvæ gain access to cattle. When they have once attached themselves to the host and begin to get nourishment in the form of blood their growth is assured.

We have already referred to the larval and nymphal stage, so-called, as observed by Curtice. In his observations each stage occupied about a week, so that at the end of two weeks the female tick is sexually mature, prepared to become fertilized, swell up and drop off to lay her eggs as the beginning of another generation. When young ticks hatched within a few days of one another are placed on cattle they do not necessarily mature at the same time. The dropping off of ripe ticks may go on some days before the animal is completely freed. In general, the time required for the tick to mature and drop off is from twenty-one to twenty-three days. These figures are the result of numercus observations made in the experiment fields at the station. The date being known when the larvæ were placed on the cattle, this period was easily determined.

The life history of the tick after it has attached itself to cattle is thus easily told. Taking two weeks for the tick to become sexually mature, the fertilization takes place as described by Curtice. An examination of the skin of cattle at this time shows each female provided with a male. After fertilization the female enlarges very slowly until from the nineteenth to the twenty-second day, when she swells up very rapidly, a day or two producing great change in size. When the proper stage is reached she loosens her hold upon the skin and drops to the ground, where the laying of eggs begins in a few days. The length of time elapsing between successive generations of ticks may be tabulated approximately as follows:

From oviposition to the larval stage (period of incubation)	20 to 45 days
From larval to adult state (parasitic stage)	21 to 23 days
Age of one generation	41 to 68 days

It should be borne in mind that the young, after emerging from the egg, may perhaps live on the fields an indefinite length of time before they gain access to cattle. We have kept them alive for several months. How they would fare under the varying conditions of moisture and dryness and of a fluctuating temperature we are unable to state, from lack of observation. This free-living period must be added to the total given above to obtain a more accurate idea of the life of a single generation. Yet it is of little importance and without doubt very brief, for when cattle are within accessible distance the young ticks soon find their way to their host.

The problem how the tick passes the winter is an important one which needs special investigation. In the warmer climates ticks are found on cattle during the winter season, and hence the development from the egg goes on during the entire year. It is highly probable that in those regions where the temperature falls too low for the tick to live on cattle the species is carried through the winter in the ovum. The great vitality of the ova is illustrated in the following experiment:

A number of dishes containing eggs were placed in a cold storeroom in the attic of the Department building during November and December, 1890, and January, 1891. The eggs were placed on the bottom of the dishes, which, otherwise empty, were covered with glass covers. They were occasionally inspected in the course of the winter and early spring, but not thereafter until July 15, 1891. It was then found that in three out of nine dishes (one placed there in November, one in December, and one in January) the embryos had developed and hatched at the approach of hot weather, but were now dead. The young ticks had left behind the little chalky masses of urates (?) over the inner surface of the dishes. In the other dishes the eggs were shriveled. Signs of development were absent. This shows that the ova lived through the winter under unfavorable conditions of moisture, since the air of the room was quite dry. The capacity of the tick to survive occasionally the winter in regions north of its natural habitat was demonstrated in an unexpected manner on the station grounds in 1891. In September of 1890 ticks hatched in the laboratory were placed on two cows (Nos. 137, 144) in a piece of woodland belonging to the station, but some distance removed from it (page 105). These contracted the disease in due time. One died during the acute attack, the other succumbed after it. The ticks, matured from this case, wintered over, probably, among the leaves under the trees, and on September 1, 1891, one young animal in this inclosure was found with many ticks attached to it, and the examination of the blood demonstrated Texas fever. The other animals in the inclosure were insusceptible Southern animals, kept over from previous years, but likewise infested with ticks. Since it is quite impossible that any ticks could have been taken to this inclosure during the summer of 1891, the explanation given above is the only admissible one. The ticks did not reappear in 1892.

Aside from the relation which the tick bears to Texas fever as the carrier of the microörganism of this disease, it is pertinent to inquire in this place what other injury this parasite might inflict on cattle. That it abstracts a certain quantity of blood during the later days of its parasitic existence is evident. The intestine is distended with a dark-red, tarry, viscid mass, from which an abundant crop of hæmin crystals may be obtained according to the well-known method of adding a crystal of common salt and some glacial acetic acid to some dried contents of the tick's body cavity on a glass slide and heating the latter until bubbles of gas are given off. These crystals show that there is much concentrated coloring matter of the blood corpuscles in the body of the tick. Yet it is doubtful whether in the aggregate very much blood is abstracted by the ticks, and the various cases under observation did not warrant the conclusion that any marked impression was made on the number of red corpuscles of insusceptible or recovered cases.

The tick produces more or less inflammation of the true skin and subcutis where it is attached. Sections of skin examined under the microscope show a very intense cell infiltration at the place of attachment, and for several millimeters around it. This infiltration is not noticed by the unaided eye. It is probable that it is due to the irritation caused by certain unknown secretions of the tick, which aid it in working its way through the upper layers of the skin and in obtaining blood in an uncoagulated state from the blood vessels attacked by it. After having attached themselves, ticks are in communication with blood vessels, for in removing them a drop of blood oozes from the place of attachment.

The young ticks attach themselves by preference to the more tender regions of the hide, such as the inner aspect of the thighs, the pubic region (escutcheon), and around and on the udder. When numerous they may attach themselves to the neck, the sides of the thorax, the ears, and even the back. In searching for them the regions first mentioned must be thoroughly examined. It must also be borne in mind that when the disease appears the ticks are still quite small and may be overlooked. Even at the time of death only a small number may have passed beyond the second moult. The ticks still within the second skin are only 3.2 mm. (about one-eighth inch) long. Those just emerged are of the same length. The more active males of the same stage are only 2 mm. (one-twelfth inch) long. The largest ticks found on animals which die during the acute attack are not more than 5 to 8 mm. (one-fifth to one-third inch) in length. When ready to drop off from insusceptible or recovered cases, they are about half an inch long (12 mm. long, 7 mm. broad, and 4 mm. thick).

In the foregoing it has been stated that the female tick remains until maturity upon the same animal to which it attached itself after emerging from the egg. Each tick, in other words, is parasitic upon but one

animal. What becomes of the ticks not yet matured, which are attached to the skin of natives when the latter succumb to Texas fever, we can not state definitely. It is certain that they do not at once leave the dead body, for in the case of cattle which die early in the night the ticks are still found attached next morning. In the case of a calf kept in a large refrigerator several were found attached forty-eight hours after death. If ticks are removed by the hand from the dead body it will be found that the males as well as those females which have passed through the second moult move about with some show of activity, while those individuals which have not yet cast off the moulted skin are motionless. Taking these facts into consideration, we must regard the movement of ticks from one animal to another as an unnatural process which, so far as we know, may take place, but which from general observations does not appear to be of much importance. Still, it is nevertheless desirable that experiments be made to determine positively whether ticks may be transplanted after the last moult, and whether at this advanced stage in their life history they are still capable of producing Texas fever.

Paquin states (9, p. 45) that full grown ticks contain the "bacteria" of Texas fever. In order to see whether ticks contain bacteria, and what kind, the following inoculation experiments were made:

(1) *July 7, 1890.*—A large North Carolina tick was taken and its back scorched through with a red hot platinum spatula, thus exposing the body cavity. A loop of the black tarry contents transferred to peptone bouillon. A coccus, arranged in the form of tetrads, produces a faint cloudiness and a deposit in the inoculated tube.

(2) A second tick from the same source treated in the same way. The culture contains a coccus of the same form.

(3) *July 10, 1890.*—From a large tick from Texas cattle a peptone bouillon tube inoculated. Remains sterile.

(4) Another large Texas tick used. The resulting peptone bouillon culture contains a flocculent growth of large bacilli in chains.

(5) *July 18, 1890.*—An agar tube inoculated from a large tick, as before. Remains permanently sterile.

(6) Another agar tube inoculated from another tick. A considerable number of small colonies develop, having an opaque center and translucent periphery. They are made up of short bacilli.

(7) A peptone bouillon tube inoculated from a large tick becomes clouded with large motile spore-bearing bacilli.

These experiments show that the tick may harbor a variety of bacteria or none at all.

FIELD EXPERIMENTS TO DETERMINE THE PRECISE RELATION BETWEEN THE CATTLE TICK AND TEXAS FEVER.

These experiments were begun in the summer of 1889 and have been continued up to the present. They have been carried on in three different directions:

(1) Ticks were carefully picked from Southern animals, so that none

could mature and infect the ground. The object of this group of experiments was to find out if the disease could be conveyed from Southern to Northern stock on the same inclosure without the intervention of ticks.

(2) Fields were infected by matured ticks and susceptible cattle placed on them to determine whether Texas fever could be produced without the presence of southern cattle.

(3) Susceptible northern cattle were infected by placing on them young ticks hatched artificially, *i. e.*, in closed dishes in the laboratory.

These three lines were not followed simultaneously because, for instance, the fact that the disease can be produced by placing young ticks on cattle was discovered in 1890, and hence only tried then and thereafter. In giving the details of the various experiments we shall adhere not to the classification given above, but rather to the chronological order in which the experiments were performed. This is necessary in order to describe successively the experiments of the same year which were more or less connected with one another and also to show the process by which the various facts concerning the cattle tick came to our knowledge.

The disease was introduced into one field each year by North Carolina cattle brought here for this purpose. In 1890 a field was infected by cattle from Texas.

The field experiments were all conducted on the experiment station of the Bureau of Animal Industry within half a mile of the limits of the city of Washington. The arrangement of the various experimental fields is shown for each year on a plat of the station grounds. The isolated condition of the field in use in any given season may be seen by an inspection of these plats. They are either separated from one another by a piece of ground remaining permanently free from infection or by a lane or by a strip of ground purposely fenced off between them. No two fields in use are thus separated merely by a fence. In every case, with the exception to be noted, a strip of ground intervenes which is at least 36 feet wide. A small brook passes through a portion of the grounds as is shown in the various plats, and the space between the fields along this brook is about 20 feet wide.

Experiments of 1889 (first series).

To carry on the experiments in the early part of the season of 1889, seven head of cattle were collected in Craven County, N. C., which is a portion of the permanently infected territory. On June 25 they were shipped by steamer from New Berne, N. C., and they arrived at the station near Washington June 27. They had thus been two days on the way. These animals were rather thin and a large number of cattle ticks (*Boöphilus bovis*) in various stages of development were attached to them. Only a few were full grown.

Experiment 1 (exposure to Southern cattle with ticks).—Of these seven head four were placed in field I (see Fig. 4) on the day of arrival, June 27. The field contains about nine-sixteenths of an acre. The soil is a dry, gravelly loam. A small stream passes through it, from which the cattle obtain their drinking water.

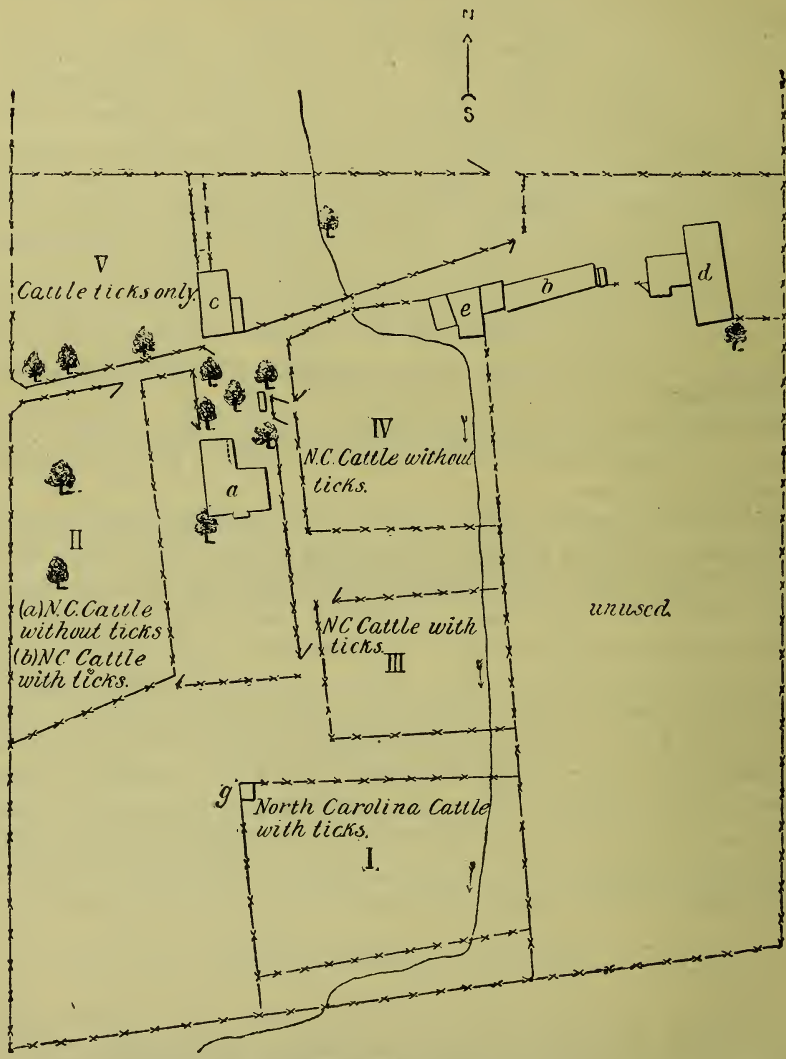

FIG. 4.—Field inclosures for 1889 (scale, ¼ inch=33 feet).
a, dwelling house; *b*, station laboratory; *c*, horse stable; *d*, cow stable; *e*, breeding pens; *f*, tool house; *g*, shed in field.

The history of the native cattle placed in this field may be briefly summarized. Notes concerning symptoms of disease, post-mortem examination, microscopical and bacteriological data, may be found in the appendix under each case.

(*a*) North Carolina cattle with ticks:

No. 12, placed in this field June 27, removed August 17.
No. 40, placed in this field June 27, removed August 17.
No. 42, placed in this field June 27, removed August 17.
No. 45, placed in this field June 27, removed August 17.

(*b*) Native cattle:

June 27, No. 7 (cow, 6 years) placed in this field. Dead* August 23.
June 27, No. 8 (cow, 1½ years) placed in this field. Killed† August 27.
June 27, No. 75 (calf of No. 8, 4 months) placed in this field. Recovered.
June 27, No. 9 (bull, 1½ years) placed in this field. Died August 31.
June 27, No. 10 (calf of No. 7, 4 months) placed in this field. Died August 31.
June 27, No. 11 (calf of No. 7, 4 months) placed in this field. Killed September 10.
August 20, No. 46 (heifer, 1¾ years) placed in this field. Killed September 10.
August 24, No. 43 (steer, 3 years) placed in this field. Dead September 13.
August 24, No. 44 (steer, 4 years) placed in this field. Dead September 17.
September 6, No. 53 (heifer, 1½ years) placed in this field. Recovered.
September 6, No. 54 (heifer, 2 years) placed in this field. Killed September 20.
September 14, No. 57 (cow, 9 years) placed in this field. No result.
September 30, No. 70 (steer, 2½ years) placed in this field. Died October 19.
October 19, No. 71 (heifer, 3½ years) placed in this field. Probably no disease.

The disease in this field was designed to furnish material for general investigation as well as to serve as a control for experiment 2 below. It illustrates admirably a number of important characters of this remarkable disease and demonstrates once again the frequently observed fact that cattle, to all appearances healthy, may become the cause of an extensive fatal disease when transferred in the warmer seasons of the year from a certain permanently infected area to territories north of this area.

The first high morning temperature appeared August 15, or thirty-nine days after the native and Southern cattle were placed on this field together. The first death occurred August 23, or forty-seven days after this same date. In other words, the cattle exposed at this time died not less than forty-seven days after the beginning of the exposure. After a certain time, however, death follows more speedily after exposure, as may be seen when we consult those cases exposed August 20 and thereafter, for which this period was only fourteen to twenty-three days. The field remained infected so as to cause death as late as October 19. The later the exposure the less likely is the disease to end fatally.

Omitting the last case, No. 71, as having been exposed too late, we have ten deaths from thirteen cases exposed, or 76.8 per cent. It should be noted that, although the Southern cattle were removed from the field August 17, the infection on the field remained unimpaired.

Experiment 2 (*exposure to Southern cattle without ticks*).—For this experiment, field II was selected (see Fig. 4). The soil is the same as

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* Unless otherwise stated the cause of sickness and death is Texas fever.

† With one exception (No. 163) all native animals reported killed in this report were in a dying condition at the time.

that in field 1, but there is no running or standing water in it. It contains one-third of an acre.

This experiment differed from the first in that the *ticks were carefully picked from the three North Carolina cattle left after stocking field I.* The picking was done by hand. On July 6 and 17, the cattle were again carefully inspected, and any ticks which had thus far escaped attention were carefully removed. On July 23 no more ticks could be detected. In this way it was expected that no ticks would mature and infect the field. The following cattle were placed in this field June 27, 1889:

(*a*) North Carolina cattle without ticks, Nos. 28, 29, and 30.

(*b*) Native cattle: No. 51 (cow, 3 years); No 52 (calf of No. 51, 4 months); No. 53 (heifer, 1½ years); No. 54 (heifer, 2 years).

On September 6, no ticks and no disease having appeared in this field, Nos. 53 and 54 were transferred to field I. Their further history is given under experiment 1. It would have been more satisfactory to have left these animals on this field until the close of the season of 1889. But the evidence is decidedly in favor of the assumption that there was no infection of these animals when they were transferred to the infected field. This evidence is twofold: (1.) The three adult animals and one calf in control field I were dead by August 31 and the remaining calf was killed in a dying condition September 10. Hence all five animals exposed at the same time in the field containing ticks were either dead or very sick on the date of the removal of these two to field I. They on the other hand were at this time to all appearances healthy. (2.) One transferred case (No. 54) was dying of an acute attack September 20, as the autopsy notes and microscopical observations demonstrate. If this animal had been affected September 6, at the time of transfer, the blood corpuscles would have shown later on enlarged and stained forms (macrocytes) always associated with prolonged disease. No. 53 first showed external signs of disease in the last week of September, at which time it lost much flesh and was very weak. In October it was passing through a mild or secondary attack. Both transferred animals, therefore, must be regarded as having contracted Texas fever after September 6 on field I. The same arguments apply to Nos. 51 and 52, which were reëxposed later on in the season (experiment 4).

Experiments of 1889 (second series).

In September of 1889 a second series of experiments were carried on in order to repeat the observations on the relation of ticks to Texas fever. Nine head of cattle were collected in Craven County, N. C. Three were taken from each of three farms located several miles from New Berne and in opposite directions from that city. The three cattle from one farm were shipped from New Berne September 10 and reached the station September 14. The remaining six were shipped September 12 and arrived September 15. The three of the lot to arrive first were

placed in their respective fields a day earlier than the remaining six. All cattle were well loaded with cattle ticks, many of which were nearly matured.

Experiment 3 (*exposure to Southern cattle with ticks*).—For this experiment field III was chosen (see Fig. 4). It resembled field I in having a running stream and contained about three-eighths of an acre. It was separated from field I by a lane 36 feet wide. The experiment was designed as a control to the others below, and in order to insure the same conditions in every respect one of each of the three lots of cattle was placed in it. The following animals were in this field:

(*a*) North Carolina cattle with ticks:

No. 113, placed in field III September 14.
No. 60, placed in field III September 15.
No. 62, placed in field III September 15.

(*b*) Native cattle:

No. 35 (heifer, 2 years), placed in field III September 14.
No. 47 (cow, 3½ years), placed in field III September 14.
No. 49 (heifer, 3 years), placed in field III September 14.

Of these three natives only No. 47 passed through a severe attack of the disease, as the notes in the appendix demonstrate. The season was somewhat too far advanced when the exposure began, and of the new generation of ticks only very few appeared on the native cattle afterward.

Experiment 4 (*exposure to Southern cattle with ticks*).—This experiment is the counterpart of experiment 3, excepting that it was conducted in field II, which is without running water. Field II, moreover, was occupied by Southern cattle without ticks in July and August, as will be seen by referring to experiment 2. From this experiment there remained in the field natives No. 51 and 52. On September 14 and 15, three North Carolina animals, one from each of the three lots, were placed in this field, and one native, No. 56, was added September 14. There were, therefore, in this field on September 15—

(*a*) North Carolina cattle with ticks, Nos. 32, 61, and 67.

(*b*) Native cattle:

No. 51 (from experiment 2). Passed through the disease and recovered.
No. 52 (from experiment 2). Passed through the disease and recovered.
No. 56 (steer, 2½ years). Probably not affected.

On October 9, ticks had almost entirely disappeared from the Southern cattle, and very few young ticks subsequently appeared on the natives. There can be no doubt of the nature of the disease in Nos. 51 and 52, as will be seen from the notes in the appendix.

Experiment 5 (*exposure to Southern cattle without ticks*).—For this experiment field IV was chosen (see Fig. 4). It covers about three-eighths of an acre, is situated above field III, and separated from it by a lane 36 feet wide. The stream passes through it on the east. Three Southern cows, one from each lot, were placed in this field after the

ticks had been carefully picked off so far as they could be seen. In this field there were the following animals:

(*a*) North Carolina cattle without ticks:

No. 55, 59, and 63, the first put on the field September 14, the others September 15.

(*b*) Native cattle:

No. 41 (heifer, 4 years) placed in this field September 14.
No. 50 (cow, 3 years) placed in this field September 14.
No. 97 (calf of No. 50, 2 months old) placed in this field September 14.
No. 66 (heifer, 1½ years) placed in this field September 14.

The Southern cows were reëxamined September 18, 26, October 1 and 9, and some remaining ticks removed. On October 9 only two or three were found. Up to November 27 no ticks were detected on the native cattle, and no symptoms of disease were noticed.

Experiment 6 (*exposure to cattle ticks only*).—This experiment was carried on in field V, an inclosure consisting of about three-eighths of an acre. The soil is a heavy clay loam, and contains neither running nor standing water. On September 13 several thousand, mostly full-grown ticks, were scattered over the ground in this field. These ticks had been collected from cattle near New Berne, N. C., September 9 and 10. There were placed in this field, September 14, four natives:

No. 48 (cow, 2½ years).
No. 83 (calf of No. 48, 2 months).
No. 64 (steer, 2½ years).
No. 65 (heifer, 2½ years).

Of these. Nos. 48, 64, and 65 contracted Texas fever. No. 83 was not examined as to its blood, but it showed no external symptoms of disease. No. 48 was killed in a dying condition, October 21. The autopsy, as well as the examination of the blood before death, demonstrated Texas fever. Nos. 64 and 65 recovered.

Summary of the Experiments for 1889.

The first series (Nos. 1 and 2) go far toward demonstrating that a field must be infected with ticks before Texas fever can appear among natives. The second series confirms the first as far as it goes. The advanced season gave rise only to what has been called the mild or autumnal type of the disease, characterized by the presence in the blood corpuscles of the peripheral coccus-like stage of the Texas-fever parasite. If we bring together the results of the four experiments we find that in the field containing the ticks only, and in which Southern cattle at no time entered, all three exposed adult natives took the disease. In the field containing Southern cattle from which the ticks had been picked no disease appeared. Finally, in the two fields which contained Southern cattle and ticks together three out of six natives became diseased. In these experiments the great importance of the method of blood examinations as described in the first part of this volume is plain. To rely upon external symptoms in mild attacks is

out of the question. The counting of the red corpuscles, the changes going on in the latter, and the presence of the Texas-fever parasite as determined by microscopical examination are indispensable in determining whether Texas fever is present or not.

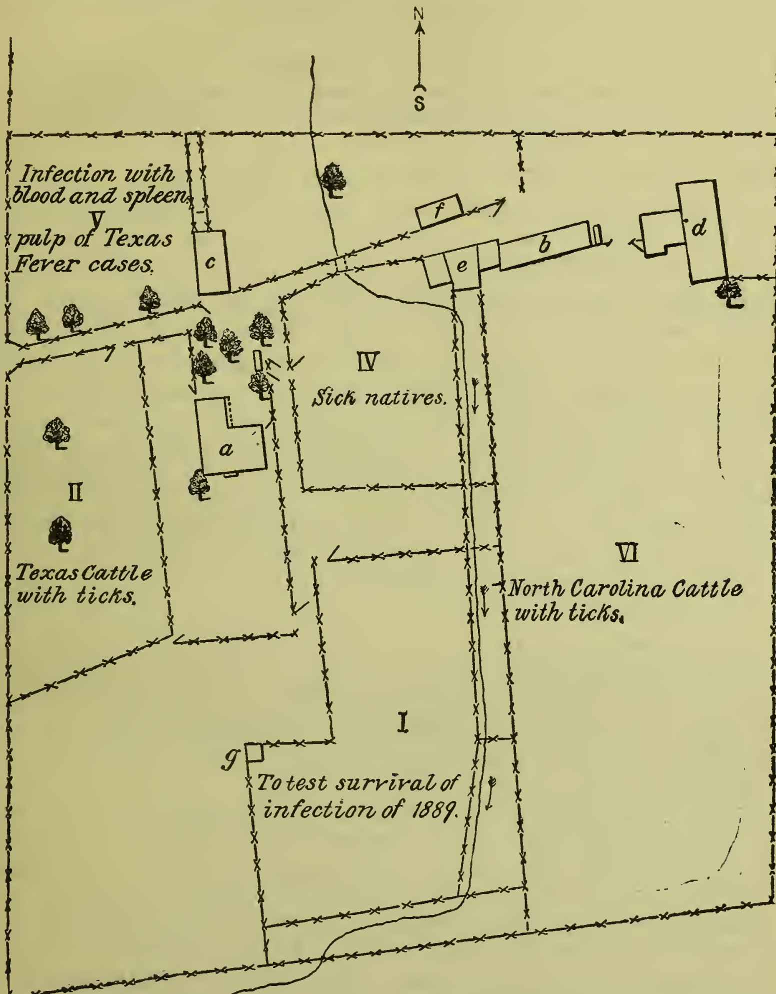

FIG. 5.—Field inclosures for 1890 (scale ¼ inch = 33 feet). For an explanation of the letters see fig. 4 on page 94.

EXPERIMENTS OF 1890.

The experiments of this year were chiefly occupied with the relation of ticks to Texas fever. The experiments of last year were repeated and in addition ticks were hatched artificially and placed on cattle with the result that Texas fever appeared in every case (experiments 12 and 13). Southern cattle were obtained as before from North Carolina (Experiment 9) and also from Texas (Experiment 8).

Experiment 7 (*to ascertain whether the infection of 1889 survived the winter*).—For this purpose fields I and III of 1889 were thrown together by removing the intervening fences and the whole designated field I (see Fig. 5). The little stream was likewise fenced off in July to prevent any infection from field VI reaching it. A number of animals were pastured on this field.

May 26, 1890.—No. 74 (heifer, 2 years.) Transferred to field II September 25.
May 26, 1890.—No. 91 (heifer, 3 years.) Transferred to field VI October1.
July 4, 1890.—(Stream fenced off, as field VI is now used for the first time.)
July 9, 1890.—No. 130 (cow, 5 years).
August 25, 1890.—No. 97 (bull, 1 year).

During the summer no ticks appeared in this field, so that it was evident that they had not survived the winter. No disease appeared in any of the animals exposed.

Experiment 8 (*to ascertain whether the disease introduced by Texas and that introduced by North Carolina cattle are the same*).—Four heifers were removed from their pasture near Houston, Tex., June 30, and sent by express to the station, where they arrived July 4. Hence, they were but four days off the Southern pasture before they were placed in field II (see Fig. 5). The heifers were in rather poor condition and all well supplied with cattle ticks of all stages. The field corresponded with field II, of 1889, but it was slightly enlarged so as to include about $\frac{9}{16}$ of an acre. The field thus contained—

(*a*) Texas cattle with ticks:

No. 124 (heifer, 2 years).
No. 125 (heifer, 3 years).
No. 126 (heifer, 4 years).
No. 127 (heifer, 5 years). All placed in field II, July 4.

(*b*) The native cattle were exposed in the following order:

July 4, No. 128 (cow, 12 to 14 years). Dies September 1.
July 5, No. 80 (cow, 7 years). Killed August 28.
July 5, No. 82 (calf, 5 months). Diseased, but recovered.
July 5, No. 107 (heifer, 1 year). Diseased, but recovered.
July 5, No. 129 (heifer, 2 years). Dies August 29.
August 30, No. 139 (cow, 6 years). Dead September 13.
September 25, No. 74 (heifer from field I). Dies October 16.
September 25, No. 62 (N. C. heifer of 1889). Exposure negative.

As regards the cattle ticks, the following observations were made. On July 30, only a few adults were still attached to the Texas cattle, the rest having disappeared. On October 20, only very few young ticks were still found on the surviving cattle, and eight days later they had all disappeared.

Any differences between the disease in this and the North Carolina fields could not be found.

Experiment 9 (*exposure to North Carolina cattle with ticks. General control field for 1890*).—Field VI was chosen for this purpose. It covers $1\frac{7}{8}$ acres, and is fenced off from the stream. Between it and the other fields (I, IV) is a strip of land containing the stream bed.

To carry on the various experiments of the year, and to infect this field, cattle were taken from North Carolina fields as in 1889. The cattle were collected July 1, shipped by steamer from New Berne, N. C., July 2, and received at the station July 4. Of those received, the following were placed in field VI on July 4:

No. 114 (heifer, 2 years), from North Carolina; farm 1.
No. 112 (old cow), from North Carolina; farm 4.
No. 120 (cow, 7 years), from North Carolina; farm 2.
No. 119 (calf of No. 120, 3 months), from North Carolina; farm 4.
No. 121 (cow, 3 years) from North Carolina; farm 4.
No. 122 (heifer, 2 years), from North Carolina; farm 3.

These Southern animals were in fair condition, excepting No. 112, which was very thin and weak. All excepting No. 114 were well supplied with cattle ticks.

The following Northern animals were placed in field VI:

July 4.—No. 49 (cow, 4 years), exposed in 1889, but probably not affected at that time.
July 4.—No. 85 (calf of No. 49, 3 months).
July 4.—No. 50 (cow, 4 years), in field IV in 1889, but not affected.
July 4.—No. 57 (cow, 10 years), exposed in field I in 1889, but probably not affected.
July 4.—No. 79 (calf of No. 50, 3 months).
July 4.—No. 66 (heifer, 2 years), exposed in field IV in 1889, but not affected.
July 4.—No. 69 (cow, 3 years).
July 4.—No. 100 (calf of No. 69, 2 months).
July 4.—No. 95 (cow, 4 years).
July 4.—No. 93 (calf of No. 95, 1½ months).
August 13.—No. 71 (heifer, 4½ years), transferred from field I.
August 13.—No. 134 (heifer, 2 years).
August 25.—No. 90 (bull, 1 year).
September 8.—No. 56 (steer, 3½ years), exposed in field II in September, 1889, but probably not affected.

These various animals (excepting Nos. 49, 56 and 57) may be regarded as unexposed natives, although some of them had been used the year previous and early in this season in fields presumably free from infection. The result of the exposure may be tabulated as follows:

No. 49 has a severe attack but recovers.
No. 85 has a mild attack.
No. 50 dies September 6, sixty-four days after the beginning of the exposure.
No. 57 is not affected.
No. 79 has a very mild attack and recovers.
No. 66 dead September 1, fifty-nine days after the beginning of the exposure.
No. 69 dies September 3, sixty-one days after the beginning of the exposure.
No. 100 has a mild attack, but succumbs in December.
No. 95 killed in dying condition, August 25, fifty-two days after exposure.
No. 93 has a mild attack.
No. 71 dead September 6, twenty-four days after beginning of exposure.
No. 134 killed in dying condition August 28, fifteen days after exposure.
No. 90 dies September 16, twenty-two days after exposure.
No. 56 has a prolonged but mild attack and recovers.

It will be seen from this table that all animals exposed in midsummer (July and August) died or were killed in a dying condition, excepting

the calves. These were all affected; one died late in the fall and one was killed, but in every case the attack was mild. The mortality among those over 1 year old was 80 per cent. It will be noticed also that animals exposed in August died with those exposed a month earlier. Those exposed on July 4, when the field was first infected, died from fifty-two to sixty-four days thereafter. Those exposed in August died in fifteen to twenty-four days after the first day of exposure.*

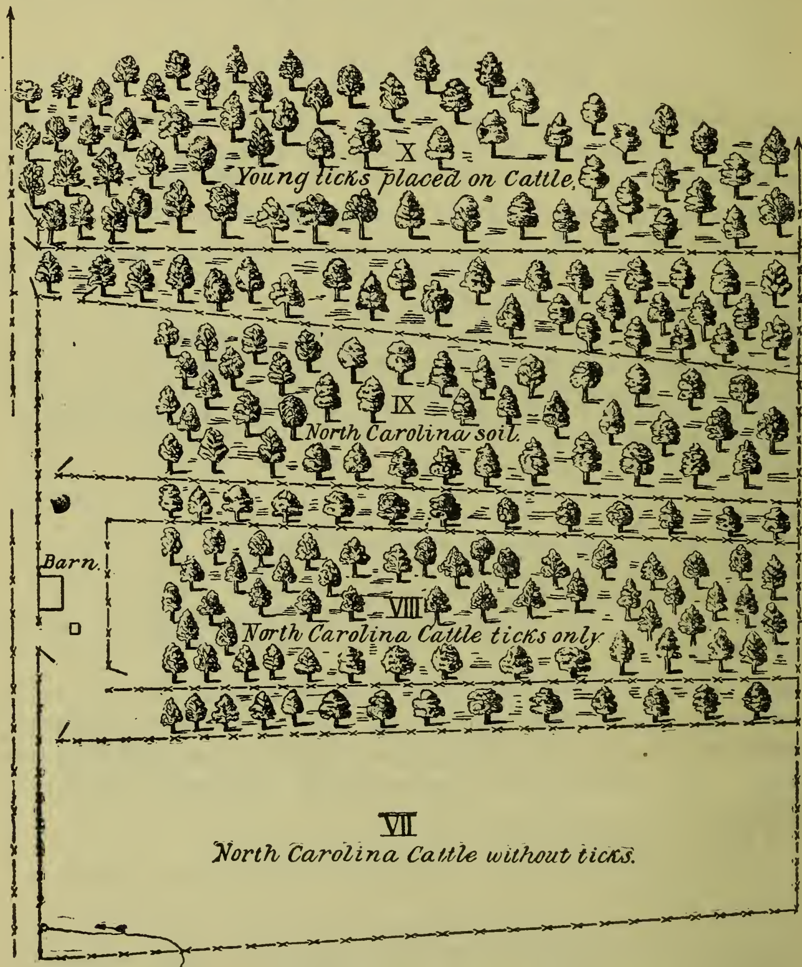

FIG. 6.—Supplementary inclosures for 1890 (scale ¼ inch = 33 feet.)

On July 30 only a few full-grown ticks were left on the Southern stock. August 13, two weeks later, young ticks had appeared on all the cattle, native and Southern alike. August 25 some of these had become full grown. In the middle of October only a few young ticks could be seen, and by the end of the month they had practically disappeared.

* In this field there were placed during the summer some animals which had passed through one attack of the disease and some Southern animals kept on the station from the year previous. These cases will be reviewed under another subject (p. 130).

Experiment 10 (*exposure to cattle ticks only*).—Field VIII was used in this experiment. (See Fig. 6.) It is a fenced-off portion of a piece of ground situated about one-fourth mile north of the station grounds upon which the experiments thus far recorded were carried on. This particular field covers about 1⅝ acres, and is separated from the adjoining fields VII and IX by strips of ground as shown in the plat. The ground is covered largely with trees (oak and chestnut) and may be regarded as sparsely wooded. It slopes towards field VII at an angle of 20°–30°. On July 4 about 4,000 matured and 1,000 half-grown ticks were scattered over the ground in this inclosure. The ticks had been collected between June 28 and July 2 about New Berne, N. C., and placed in a large can containing grass from the Washington station. At the time they were scattered over the field many had already laid a portion of their eggs.

In this field were placed the following native cattle:

July 4.—No. 76 (heifer, 1 year).
July 4.—No. 102 (cow, 6 years). No. 102_a (calf of No. 102, born on this field September 1).
July 4.—No. 105 (heifer, 2 years).
August 21.—No 47 (cow, 4½ years, recovered case of 1889).
August 21.—No. 135 (heifer, two years).

The result of the exposure is briefly as follows:

No. 76 killed in dying condition August 18.
No. 102 very sick with Texas fever, but recovered.
No. 102_a died of Texas fever thirteen days after birth.
No. 105* very sick, but recovered.
No. 47* died September 12.
No. 135* very sick but recovered.

Of the six cases exposed to the ticks only, all were unmistakably affected with Texas fever, as the notes in the appendix show. Three died and the autopsy confirmed the diagnosis. The reason why the mortality was not so high here as in the preceding experiment is probably to be sought for in the fact that under natural conditions the young ticks appear more successively and cause a more prolonged infection, while in this experiment they probably appeared nearly all at the same time.

The young ticks were seen in this field August 8, and on August 23 full grown specimens were found on No. 102.

Experiment 11 (*exposure to Southern cattle without ticks*).—This experiment was conducted on field VII adjoining the field of the preceding experiment. (See Fig. 6.) It covers about 1¾ acres and contains both running and standing water from a spring. It is not wooded. The following Southern cattle brought from North Carolina (with those

* These cases were transferred subsequently to an uninfected field in order to determine whether they could communicate the disease to other natives. (See appendix under each case and p. 122.)

placed in field VI of this year) were put into this inclosure after all ticks that could be found were carefully removed:

July 4.—No. 115 (cow, 6 years) from farm 4.
July 4.—No. 116 (heifer, 2 years) from farm 2.
July 4.—No. 117 (heifer, 2 years) from farm 3.
July 4.—No. 118 (cow, 10 years) from farm 4.
July 4.—No. 123 (heifer, 3 years) from farm 1.

Into this inclosure were placed on the same day the following native cattle: No. 103 (heifer, 3 years); No. 106 (heifer, 2 years); No. 108 (heifer, 2 years).

The Southern cattle were reëxamined three times a week between July 7 and July 28, to remove any ticks which on account of their small size had escaped detection. On a final examination July 30 no more could be found.

Nevertheless, on August 15, a few young ticks were found on the natives, and three days later a large number had attached themselves. The outcome was the death of the three natives. No. 103 died August 28; No. 106 died September 6; No. 108 died September 9.

The experiment had thus failed in so far as ticks had not been kept out of the field. Although it is not to be denied that some may have escaped attention and fallen to the ground, yet it is highly probable that most if not all the ticks or their eggs were washed in from the adjoining field VIII, which is considerably higher and slopes toward VII. There had been exceptionally heavy showers August 1 and August 8, which had carried much soil, and even stones as large as a fist, into this field. At all events, this difficulty might have been avoided by reversing the location of the two experiments and placing the animals free from ticks on the higher ground.

Experiment 12 (*production of Texas fever by placing on native cattle young ticks artificially hatched in the laboratory*).—Hitherto we had supposed that the cattle tick acts as a carrier of the disease between the Southern cattle and the soil of the Northern pastures. It was believed that the tick obtained the parasite from the blood of its host and in its dissolution on the pasture a certain resistant spore form was set free, which produced the disease when taken in with the food. The feeding of one animal (No. 145) for some time with grass from field VI, the most abundantly infected of all, without any appearance of disease made this hypothesis untenable. But even before this feeding experiment was undertaken other facts were noticed which militated against this hypothesis and which proved that the young tick calls forth the disease. In the first place, animals exposed when the field was first infected did not die until fifty to sixty days after the beginning of the exposure, while those exposed thirty or more days later on the same ground died in fifteen to twenty-five days thereafter. In the second place, all animals which succumbed had young ticks on them. In other words, the appearance of the disease was in some manner associated with the appearance of the new generation of ticks. Even

with this fact fairly well determined the true explanation that the young ticks were directly responsible for the disease seemed too far-fetched to deserve attention until it was demonstrated in the following manner. A yearling heifer (No. 138) had been placed in a box stall and a number of young ticks, hatched artificially in glass dishes, had been placed on this animal at intervals, beginning August 14, in order to determine whether ticks in the capacity of blood-sucking parasites made any impression on the number of blood corpuscles. It was found by a periodical estimation of the number of red corpuscles that after a certain time this number fell so quickly and so markedly as to be wholly incommensurate with the small amount of blood abstracted by the ticks. At the same time other symptoms of Texas fever appeared and the parasite was detected in the blood.

The experiment was repeated on several other animals as soon as young ticks could be obtained.

No. 140 (heifer, 2 years old) kept in a box stall on a neighboring farm. The young ticks 3 to 4 days old were placed on it September 9. It was found dead October 2. Both blood examination during life and the autopsy demonstrated Texas fever.

No. 137 (heifer, 1 year old) was placed in field X, a wooded lot to which no infected cattle had been admitted, and on September 9 young ticks were placed on it. It passed through a severe attack of Texas fever and was killed in a dying condition November 6.

No. 144 (cow, 8 years old) was also kept in field X. The young ticks were placed on it September 17 and it was found dead October 3. In this case also the nature of the disease was beyond question.*

Experiment 13 (*production of Texas fever in the winter season by placing young ticks on cattle kept in an artificially-heated stable*).—The result of experiment 12 was so important that it was deemed best to repeat it in an artificially-heated stable, as the season was too far advanced for ticks to thrive in the open air. The stable was warmed by means of a coal stove. The temperature fluctuated between 65° and 80° F. A complete history of all the cases experimented on in this way is given in the appendix.

The following animals were exposed and infected with young ticks:

No.	Age, etc.	Placed in stable.	Infection with ticks.	Number of infections.	Result.
143	Heifer, 1½ years	Oct. 27, 1890	Oct. 28–Nov. 8	2 (200–300 each time).	Slight, if any effect.
145	....do	....do	Nov. 21–Dec. 3	7 (200–300 each time).	Prolonged case of Texas fever. Recovered Mar. 18, 1891.
149	....do	....do	Oct. 28–Nov. 21	6 (15 each time)	Slight, if any effect.
117[1]	Southern heifer, 2 years.	Nov. 19, 1890	Nov. 21–Dec. 3	7 (200–300 each time).	Do.
130	Cow, 2 years	Dec. 12, 1890	Dec. 13–Dec. 29	9 (200–300 each time).	Marked case of Texas fever. Recovered Feb. 18, 1891.
152	Cow, 4½ years	....do	....do	9 (200–300 each time).	Mild case of Texas fever. Recovered Jan. 20, 1891.

[1] In stall with No. 145.

The young ticks placed on Nos. 117, 143, 145, and 149 were descended from adults picked from diseased natives (Nos. 137, 138, and 140). Those placed on Nos. 130 and 152 were descended from adults received directly from North Carolina.

* For full details concerning the ticks and the course of the disease in these cases see appendix.

This experiment demonstrates that Texas fever may be produced at any season of the year if the conditions are fairly favorable; if, in other words, the temperature of the air is sufficiently elevated to permit the cattle tick to carry on its parasitic existence. Of five presumably susceptible animals infected with ticks three showed well-marked symptoms of Texas fever, and the remaining two reacted with a high temperature for a few days. In these latter cases there may have been a reduction in the number of red corpuscles also, but we can not regard such reduction demonstrated until the number falls below 5,000,000. The temperatures taken twice a day will be found in the appendix, and we limit ourselves here to the following extracts:

No. 143. Temperature 104 to 105.3 on November 21 to 23, inclusive.
No. 145. Temperature 104 to 106 on December 4 and 5.
No. 145. Temperature 104 to 105 from January 19 to 27.
No. 149. Temperature 104 to 105 on November 12, 13, and 25.
No. 117. Temperature 103.8 on November 26, and 103.4 on December 16 and 17.
No. 130. Temperature 104 to 106.4 from December 26 to January 1, and 103 to 104 on January 9.
No. 152. Temperature 103.8 to 106.3 on December 27 to 31.

In these cases the high temperature appeared generally in fifteen days after the first lot of young ticks had been put on the animal. In No. 145 the period of marked destruction of red corpuscles was associated with high fever.

This experiment does not definitely prove that the progeny of ticks collected from susceptible Northern animals which have passed through the disease may produce as severe an attack as those descended from ticks picked directly from Southern animals. The positive result in No. 145, infected with "Northern" ticks, is vitiated by the fact that this animal was in the same stall with a Southern cow, No. 117. The severe secondary attack appeared in No. 145 in the middle of January. This would allow time for the ticks to mature on No. 117, and the next generation to attack No. 145. Hence No. 145 may actually have received the severe secondary infection from "Southern" ticks, in so far as they were descended from those matured on No. 117. This interpretation may be wrong and the secondary infection in No. 145 may have been a true relapse resulting from the primary infection with "Northern" ticks. The experiment as it stands, however, can only be interpreted as showing that ticks produce well-marked disease in artificially-heated stables in winter, and the other question, whether "Northern" ticks may do this, must be left open.

Summary of the experiments of 1890.

The discovery of 1889 that ticks alone are sufficient to infect a field was confirmed this year. The experiment designed to test the theory that Southern cattle are infectious only through the ticks they carry failed this year for the field became infected with ticks after all. Lastly, the demonstration of the important fact that the infection is

conveyed by the young tick, and is probably introduced by it into the blood, was a very great stride in advance in our understanding of the external characters of the infection.

In field IX (see Fig. 6) several natives were exposed to North Carolina soil without becoming diseased.

On the station grounds field V (see Fig. 5) was infected with the blood and spleen pulp of cattle which had succumbed to Texas fever. The exposed natives did not become infected.

In field IV (see Fig. 5) during this same year a number of sick natives were brought together and some healthy natives added. The latter had a mild attack late in the season, only detected by the microscopic examination of the blood.

These three experiments will be fully discussed farther on, and we simply refer to them here to show that the animals not exposed under certain conditions did not become infected although pastured not far from Texas-fever cases during the summer.

Experiments of 1891.

The arrangement of the fields for this year and the uses to which they were put are indicated on the accompanying plat. A tract of land adjoining the station grounds on the north was added to the territory in use. On this tract were situated a dwelling house and a number of unused sheds. For the purpose of carrying on the various experiments, cattle were collected near New Berne, N. C., as in previous years, and shipped by steamer from New Berne, June 30. They arrived at the station July 2, having been but two days on the way.

Experiment 14 (*exposure to North Carolina cattle with ticks*).—The general control experiment of producing the disease in the natural way was conducted, as before, by exposing natives to Southern animals on the same field. For this purpose inclosure VI was again selected (see Fig. 7). In this experiment not only unexposed natives but also recovered natives were reëxposed to test any acquired immunity (p. 133). Similarly Southern animals, kept for one or two years on the station, were reëxposed to determine any loss of immunity (p. 131). These collateral experiments will be discussed in dealing with these subjects. In this place we simply summarize the results of the exposure of fresh natives.

The animals placed in this field comprised the following:

(*a*) North Carolina cattle:*

July 2—No. 172 (cow, 6 years), from farm No. 6.
July 2—No. 174 (cow, 3 years), from farm No. 5.
July 2—No. 177 (cow, 5 years), from farm No. 3.
July 2—No. 178 (cow, 4 years), from farm No. 2.

* Eight animals were brought North, two from each farm, and divided equally between this and the following experiment.

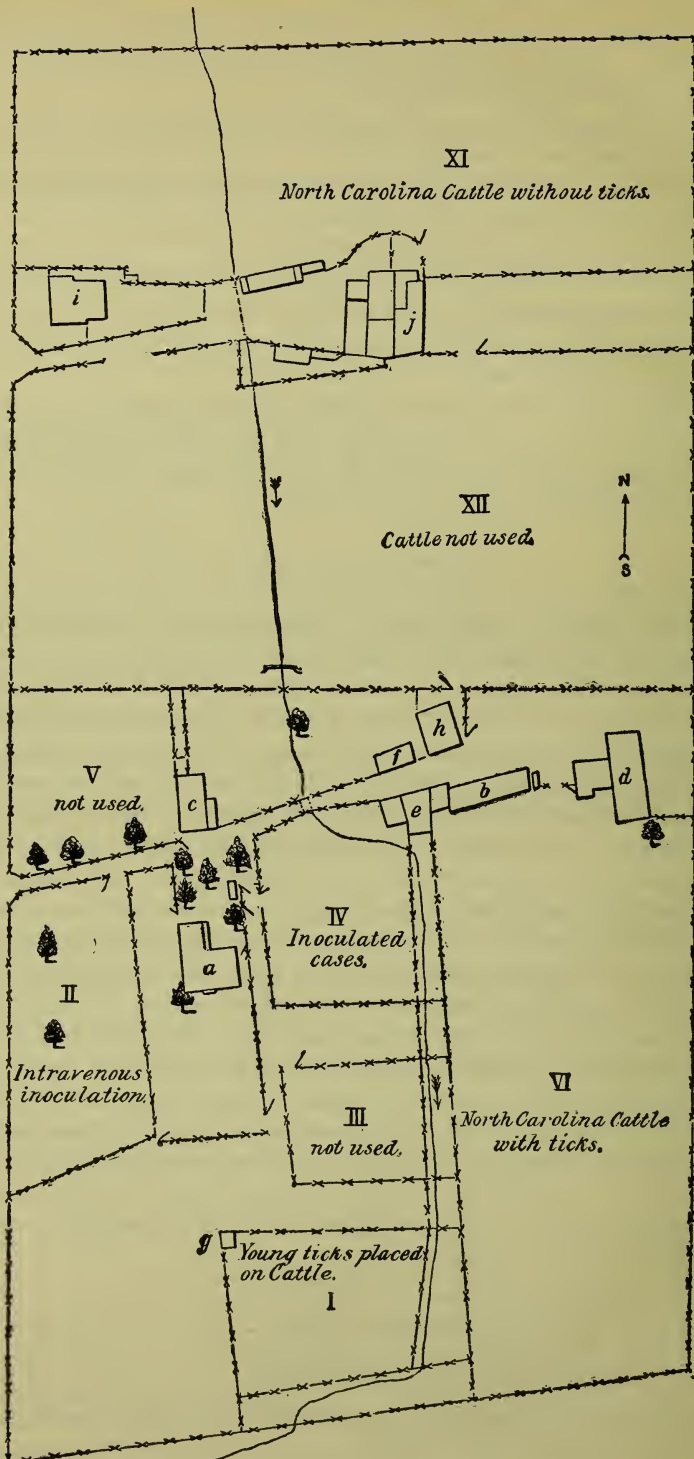

FIG. 7.—Field inclosures for 1891 (scale ¼ inch = 36⅔ feet). *a* to *g*, as in Fig. 4; *h*, swine pen; *i*, dwelling house; *j*, cow stalls.

(*b*) Natives:

July 2—No. 104 (cow, 4 years). Very sick; recovered.
July 2—No. 159 (heifer, 2 years). Not very sick; recovered.
July 2—No. 163 (cow, 6 years). Very sick; killed August 25.
September 1—No. 169 (cow, 8 years). Died September 14.
September 1—No. 181 (cow, 2½ years). Killed in dying condition September 19.
September 15—No. 184 (heifer, 2 years). Died October 2.
September 21—No. 160 (cow, 2½ years). Prolonged attack; recovered.
September 21—No. 187 (calf of No. 160, 4 months). Not affected.

All animals excepting the calf were attacked by Texas fever. No. 163 was killed at the height of the fever and probably would have died. The mortality among these animals was lower than in the preceding year, the conditions being precisely the same. Among those exposed later on, the mortality was higher than among those exposed early. The ticks in this field had entirely disappeared from the Southern stock by the end of July. The young ticks had appeared in considerable numbers on all the cattle August 10 and continued to increase in number during August on all cattle alike. They had all disappeared by the last of October.

Experiment 15 (*exposure to North Carolina cattle without ticks*).—The great importance of determining whether or not the ticks are the only carriers of the infection from the permanently infected regions of the South imposed upon us the necessity of trying this experiment until it could be stated with certainty that no ticks had passed from Southern to native cattle. The experiment of 1890 (Exp. 11) had failed because young ticks had appeared on the natives in course of the summer. For the repetition of this experiment the hitherto unused inclosure XI (see Fig. 7), covering over 2 acres, was chosen. The following North Carolina cattle were put into it July 2, after the ticks had been carefully picked off: No. 173 (cow, 3 years), from farm 6; No. 175 (cow, 4 years), from farm 5; No. 176 (cow, 6 years), from farm 3; No. 179 (cow, 5 years), from farm 2.

The following natives were added at the same time: No. 161 (cow, 6 years); No. 164 (cow, 7 years); No. 167 (heifer, 3 years).

The Southern animals were reëxamined daily and a few small ticks found each day until July 22. Thereafter very few were found and after July 29 none. Nevertheless a few adults must have escaped and dropped on the ground, for young ticks made their appearance, though in small numbers, in August. From August 22 to September 3 several hundred were removed from the three natives. No. 164 was most abundantly infected. Next came 167 in this respect. No. 164 suffered a severe attack and was found dead September 3. No. 167 likewise passed through a severe attack, but recovered, while in No. 161 signs of infection were not detected, as will be seen by an examination of the notes in the appendix. The severity of the disease was thus in general proportional to the number of ticks found on these animals.

Experiment 16 (*production of disease with young ticks hatched artificially*).—This is a repetition of experiments 12 and 13 of last year, but is made much earlier in the summer. A large number of adult ticks were collected June 25–27 from cattle near New Berne, N. C. An abundance of eggs had been laid by July 7, which were placed in glass dishes containing a few fresh leaves and a few drops of water and covered snugly with a piece of glass. The young ticks began to appear July 23.

July 25, Nos. 166 and 180, both 2-year old heifers, were placed in field I (see Fig. 7). To the rump and neck young ticks were applied daily for 10 days until August 4. No. 166 received from 200 to 300 daily, No. 180 only 20 to 30 daily. After each application the heifers were held quiet for a few minutes until the young ticks had crawled away through the hairs.

July 29, No. 158, a 2-year old steer, was placed on the same field and several thousand ticks from the same lot applied at one time.

August 20, No. 117, a North Carolina heifer of 1890, was placed in the same inclosure and several thousand ticks of the same lot applied at one time.

The following table summarizes the experiment. The full notes of each case are reserved for the appendix.

No.	Age, etc.	Young ticks applied.	Number of applications.	Result of exposure.
166	Native heifer, 2 years	July 25–Aug. 4	10 (200–300 each time)	Severe attack; recovered.
180	....do	....do	10 (20–30 each time)	Severe attack; died Aug. 12.
158	Native steer, 2 years	July 29	1 (several thousand)	Severe attack; recovered.
117	Southern heifer	August 30	1 (several thousand)	No result.

In all natives a marked case of Texas fever was produced, which proved fatal in that animal to which the smallest number of young ticks had been applied. It is also interesting to note that in this experiment Texas fever appeared much earlier than in field VI (experiment 14), when the infection took its natural course. Thus in the latter field the disease was observed first August 18, while among the artificially infected it appeared as early as August 7.

Experiments of 1892.

The field work of this year was mainly directed towards determining whether or not Texas fever is transmitted without ticks. The experiments of the two preceding years had failed, because young ticks appeared on the native cattle though they had been very carefully removed from the Southern animals. This year the experiment was tried over again, and with entire success. The young ticks did not appear on the native cattle, and the latter remained free from disease in

spite of the presence of North Carolina cattle. Another very important fact was demonstrated. Texas fever was produced in natives by the intravenous injection of blood from healthy North Carolina cattle, and natives exposed to these sick natives did not contract the disease because ticks were absent.

The Southern animals used in the field work of the summer were six in number, gathered together from two farms near New Berne, N. C., three being taken from each farm. They left New Berne by steamer June 29, and reached the station July 1, being off their native fields about four days before they were placed in the fields at the station.

The field inclosures for this year are numbered as they were last year. Hence the plat of 1891 (Fig. 7) will serve to illustrate the experiments to be described.

Experiment 17 (*exposure to North Carolina cattle with ticks*).—This experiment was to serve as a control upon the following experiments. Field VI was again used for this purpose. Two Southern animals, one from each North Carolina farm, were introduced as sources of the infection. The contents of the field and the general results of the exposure may be tabulated as follows:

June 30, 1892.—No. 201 (cow, 5 years). Removed to uninfected field July 20; not diseased.
June 30, 1892.—No. 203 (cow, 6 years). Died of Texas fever August 22.
July 1, 1892.—No. 216 (North Carolina cow, 6 years).
July 1, 1892.—No. 217 (North Carolina cow, 6 years).
July 20, 1892.—No. 220 (steer, 2½ years). Very sick; recovered.
July 20, 1892.—No. 223 (heifer, 6 years). Died of Texas fever August 23.
August 26, 1892.—No. 204 (bull, 2½ years). Very sick; recovered.

On July 20 only a few half-grown ticks were found on the Southern cows. On August 5 the young ticks were first noticed on the natives; at this time they had probably been on the cattle only two or three days. The outcome of the exposure does not differ from that of preceding summers. All exposed animals contracted Texas fever, and two of the three early exposures died.

It is interesting to note that No. 201, though it was pastured on the infected field for twenty days, remained perfectly healthy, because it was removed to an unused field (IV) *before the young ticks had appeared in the infected field.* It is likewise worthy of notice that No. 223, though exposed twenty days later than No. 203, became infected at about the same time and died only a single day later. The reason for this has already been pointed out, but it deserves repetition. The infection of the field is established when the young ticks have hatched, and not before. Hence a field is not dangerous until twenty or twenty-five days (according to the average temperature) after Southern cattle have pastured on it.

Experiment 18 (*exposure to North Carolina cattle without ticks*).—Field I (see Fig. 7) was used for this test. Two North Carolina cows (Nos. 212 and 213), one from each farm, were chosen, so as to make the

conditions as nearly like those in the control field as possible, and the ticks carefully picked off before they were placed in this field. They were subsequently examined daily, as will be seen from the notes in the appendix under each case, for any ticks too small to be seen originally. Two native cows (Nos. 208 and 209) were placed in the inclosure with them. These remained perfectly well throughout the summer.

Experiment 19 (*exposure to North Carolina cattle without ticks*).—This is an exact duplicate of the preceding experiment, to insure the success of one in case the other failed, by reason of the appearance of young ticks. Two North Carolina animals (Nos. 214 and 215), one from each farm, were carefully picked over and all ticks removed so far as they could be detected. They were placed in field No. II, July 2. Two native cows (Nos. 205 and 210) had been placed in the same field two days before. The Southern animals were carefully reëxamined for ticks, as in the experiment preceding, for several weeks. In this field no disease appeared during the entire summer. The results of the examination of the blood of these cases at different intervals are to be found in the appendix.

The cases in these fields may be tabulated as follows:

Field I.

July 2—No. 212 (North Carolina cow, 3 years).
July 2—No. 213 (North Carolina cow, 5 years).
Jnne 30—No. 208 (cow, 5 years). Exposure negative (October 1).
June 30—No. 209 (cow, 9 years). Exposure negative (October 1).

Field II.

July 2—No. 214 (North Carolina cow, 4 years).
July 2—No. 215 (North Carolina cow, 4 years).
June 30—No. 205 (cow, 5 years.) Exposure negative (October 1).
Juue 30—No. 210 (heifer, 2 years.) Exposure negative (October 1).

MISCELLANEOUS EXPERIMENTS.

Experiment 20 (*to test infection by way of the digestive tract*).—No. 131, a heifer, 2 years old, was placed in a box stall July 29, 1890, and fed at three intervals about 2,000 adult live ticks in all. The animal remained well. No blood examinations were made.

No. 110, a heifer, one year old, was placed in a box stall August 14, 1890, and fed several thousand young ticks and egg cases. The result was to all appearances negative. Unfortunately the blood was not examined.

No. 145, a heifer, 18 months old, was placed in a box stall September 17, 1890, and fed once daily with one-fourth bushel of grass cut from the infected field VI together with hay and mill-feed. The experiment was closed October 12. No indications of disease during the feeding or until November 21, when it was used in another experiment (see appendix).

Experiment 21 (*to test presence of infection in young ticks*).—August 29, 1891, a large number of young ticks nearly 1½ months old, and still confined in the glass dish in which they were hatched, were crushed in a mortar in sterile distilled water. The turbid brownish liquid was filtered through two thicknesses of filter paper. A portion of this filtrate was passed through a Pasteur filter to remove organisms of every kind.

No. 165 (heifer, 2½ years) receives into the right jugular vein 10 cubic centimeters of the fluid passed through the Pasteur filter.

No. 183 (heifer, 2½ years) receives into the right jugular vein 5 cubic centimeters of the turbid fluid not passed through a Pasteur filter. Repeated examination of the blood in both cases failed to show any disease.

In 1892 a similar experiment was tried with equally negative outcome. Nos. 202 and 207 were used for this purpose and their history together with the blood examinations may be found in the appendix.

The result of these two experiments is at present inexplicable. The crushed ticks introduced into the blood fail to produce any infection whatever, while ticks from the same lots when placed on the skin (see No. 224) produce Texas fever. The experiment simply demonstrates our incomplete knowledge of the life history of this parasite.

GENERAL SUMMARY OF THE FIELD EXPERIMENTS RELATING TO THE CATTLE TICK.

We are now in a position to review the results of the field work of the past four summers and determine how far they enable us to draw definite conclusions. In addition to the general control experiments (Experiments No. 1, 3, 4, 8, 9, 14, and 17) by which Texas fever was produced in the natural way in natives which pastured on the same ground with Southern (North Carolina and Texas) cattle, experiments have been carried on in the three directions outlined on p. 92.

(1) Experiments with Southern cattle from which the ticks were picked off were made every year. (Experiments No. 2, 5, 11, 15, 18, and 19.) Those made in 1889 and 1892 were successful. Those made in 1890 and 1891 failed because young ticks appeared subsequently. The conclusion from these experiments that the tick is necessary to cause infection in Northern cattle may be regarded as demonstrated.

(2) Experiments to show that fields may be infected by cattle-ticks alone were made in 1889 and 1890. (Experiments No. 6, 10.) In both Texas fever was produced.

(3) Experiments to show that young ticks artificially hatched produce Texas fever when placed on susceptible cattle were made in 1890, 1891, and 1892. (Experiments No. 12, 13, 16, and Nos. 224 and 225.) These were uniformly successful in the summer and fall months.

It was observed, however, that the disease induced by such ticks is less fatal than that produced in the fields in the natural way. We are

not prepared to account for this difference, unless it be the mode of incubation. The artificial condition of heat and moisture under which the eggs are kept may lead to a speedy destruction of the microparasites which are in some unknown way associated with them.

THE RELATION OF THE CATTLE TICK TO THE "PERIOD OF INCUBATION" OF TEXAS FEVER AND TO THE INFECTIOUSNESS OF SOUTHERN CATTLE.

In the foregoing experiment everything points to the cattle tick as the natural transmitter of the disease. It has been definitely demonstrated by our experiments that not only fields may be infected by simply scattering matured ticks over them, but that cattle themselves may be infected in stables away from all infected ground by placing on them young ticks artificially hatched.

We are now in a position to understand the peculiar variability in the period of incubation. We have seen from the experiments related that when native cattle are exposed to Southern cattle on a given field the period elapsing before the disease appears is generally over forty-five days, and the first deaths usually occur one or two weeks later, as is illustrated by the following table:

Year.	Experiment.	Date of exposure.	First high morning temperature.	First death.	Number of days after exposure.
1889	1	June 27	Aug. 15	Aug. 23	57
1890	9	July 4	Aug. 18	Aug. 27	54
1890	8	July 4 and 5	Aug. 23	Aug. 29	55
1891	14	July 2	Aug. 18	Aug. 29	58
1892	17	July 1	Aug. 16[1]	Aug. 22	52

[1] There was a period of high evening temperature in this field July 20-25, the significance of which is not clear.

This long period coincides with the time necessary to produce a new generation of ticks. When Southern cattle graze on a certain pasture in early summer, say for a day only, a few ripe ticks drop off. They lay their eggs in about seven days. These are hatched in about twenty days and are at once ready to crawl on cattle. Ten days thereafter the first high temperature usually appears. If we add these figures together we find that the disease may appear about thirty-seven days after the field was infected.* To be sure these figures are liable to fluctuations, which may make this period much longer or perhaps a little shorter at times.

When Southern cattle are placed on a certain field and kept there, as in our experiments, the field becomes much more abundantly infected with ticks, for the reason that all the ticks in their various stages ripen and fall on the same ground. Hence there is a continuous infec-

*In 1890 the Texas-fever parasite was first detected in the blood (No. 95) 34 days after the first day of field infection.

tion of the field going on for several weeks, until all the ticks originally attached to the Southern cattle have disappeared. This may increase the severity of the disease.

But how may we account for the fact that cattle placed on infected pastures later may become diseased at the same time and may die in less than fifteen days after the first day of exposure? Simply by taking into account the fact that cattle exposed late are at once attacked by the young ticks already present on the field. Hence, if we allow ten days for the fever to appear after the ticks have crawled on the cattle the mystery is at once explained.

The explanation of unusually prolonged periods of incubation is equally simple. They are associated with very early importations of cattle and the low temperature retards the development of the young in the egg. We have already shown that this development may be greatly retarded by cold, and we have observed periods of incubation ranging from twenty to forty-five days and have kept eggs over winter which developed when the temperature became warm enough the following spring.*

Billings has compiled a table (8, p. 47) embracing ten outbreaks of Texas fever which have occurred in various Western States since 1868. The period elapsing from the date of exposure to that of the first death ranges from thirty-three to ninety days. Leaving out of account these two extreme periods, the remaining ones range between forty-six and sixty-five days. The short period of thirty-three days is probably due to the fact that the native cattle were exposed on a field which had been infected some time before and on which the tick eggs had consequently undergone more or less development. This is made highly probable by putting this outbreak with the one after it in the table.

(6) Tolono, Ill., June 25, 1868 (date of arrival of Texans)......July 28 (first death). Period 33 days.

(7) Sodorus, Ill., June 1, 1868 (date of arrival of Texans)......July 28 (first death). Period 56 days.

Tolono and Sodorus are on the same railroad and but 5 miles apart. The Sodorus fields were infected June 1 and the period of incubation is fifty-six days, the usual time. The Tolono fields were most likely infected at the same time, since the first death occurred at both places on the same day. That they were not also infected twenty-five days later we do not pretend to gainsay. At this time of the year, *i. e.*, June and July, the period of thirty-three days is somewhat short for the appearance of a new generation of ticks, and the explanation given will clear up this difficulty. Billings has furnished a very good illustration (8, p. 47) of the prolongation of the period between infection of pastures and the appearance of the disease in an outbreak at Tekamah, Nebr., studied by him in 1887. The Texans infected the field as early as April 1 or thereabouts, but the disease did not appear until ninety days thereafter.

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* See p. 90.

There is general unanimity on this point, that a long period elapses between the date of infection of a given pasture and the appearance of the disease, so that further illustrations may be dispensed with. In searching over all the various publications on this subject we have not yet encountered any authentic statement which gave dates to support its claims that Texas fever ever appeared on a field within thirty days of the time that it was entered by tick-bearing cattle. If there are any such outbreaks, they may have been produced either by ticks wintering over in the egg or by an infection of the field earlier than that actually noted. It is not improbable that Southern animals may accidentally carry some eggs of ticks nearly hatched on their feet or other parts of their body. In such a case disease might appear several weeks earlier. The same would be true if ticks which have once attached themselves to cattle may, after being accidentally torn or brushed off, crawl upon natives, provided they are still infectious.

The relation of young ticks to Texas fever explains why natives placed in an infected inclosure at various intervals before the appearance of the young ticks will all contract the disease at the same time. They may mingle with *freshly arrived* Southern stock for twenty or twenty-five days before becoming infected. If removed at the end of this period *before* the appearance of young ticks they remain healthy. (See Expt. 17, page 111.) We now understand why natives placed on an infected field after the young ticks have appeared will contract Texas fever in ten to fifteen days. The life history of the tick likewise explains the frequently observed fact that Southern cattle lose the power of infecting Northern pastures after a certain number of days. We have already stated that the ticks on Southern cattle gradually disappear as they become matured. It is evident that when all have dropped off, the power of the cattle to infect fields is lost. It is possible to give the exact period of time required, provided we know the time which has elapsed since Southern cattle left their pastures, where they are being continually infected with young ticks. On the station pastures the time required for all the ticks to disappear was twenty-five to thirty days. Very soon thereafter the young ticks, descended from the ticks which matured first, appeared on all cattle, and the Southern animals again became infectious. The maturation of the second generation may push the period of disease into the fall and thereby rob it of its fatality.

We now likewise understand how cattle driven slowly northward lose their infection after a time. As soon as they have left the territory where ticks abound they receive no more accessions of young ticks and they are continually dropping mature ones. After twenty-five to thirty days, or perhaps sooner, they have parted with all and are henceforth harmless to Northern stock.

Let us now review briefly what occurs when Southern tick-bearing cattle are placed on the same inclosure with natives. If the animals be brought together early in July, as in our experiments, nothing un-

usual will be noticed for weeks. The ticks on the Southern animals slowly mature, swell up, and drop off, one by one, so that after three or four weeks all have practically disappeared. If during the second week in August the cattle be carefully examined, young ticks will be found attached to the skin and buried within the coat of hair. They may be overlooked if the examination is superficial and hasty. A week later, generally in the third week in August, the temperatures of all exposed native cattle suddenly rise to 105° or 107° F. within a few days of one another. The ticks at this time are still quite small, and have not yet passed through the second molt. Even at the post-mortem examination of many cases only small, immature ticks are found. If the natives survive the attack, the ticks mature, swell up, and drop off, ready to give birth to a second generation if the season permits.

THE RELATION OF THE CATTLE TICK TO THE MICROÖRGANISM OF TEXAS FEVER.

The hypothesis which seemed most plausible after the experiments of 1889 was that the tick, while withdrawing the blood from Southern cattle, drew out in it the Texas-fever parasite, which, entering into some more resistant state, perhaps some spore state, was disseminated over the pastures when the body of the mother tick became disintegrated. These spores were then supposed to enter the alimentary tract with the food and infect the body from this direction. The later experiments, however, completely demolished this conception. Neither the feeding of adult ticks and tick eggs* nor the feeding of grass* from infected pastures gave any positive results. On the other hand, the unmistakable outcome of the experiments was that the young tick introduced the infection into the body. This fact implies two possibilities. Either the tick is a necessary or a merely accidental bearer of the micro-parasite. If a necessary bearer of the infection, we must assume that the latter undergoes certain migrations and perhaps certain changes of state in the body of the adult tick and finally becomes lodged in the ovum. Subsequently it may become localized in certain glands of the young tick and discharge thence into the blood of cattle. This hypothesis assumes a complex symbiosis between the tick and the parasite on the one hand and the cattle and the tick on the other. According to another, simpler hypothesis the tick would be merely an accidental bearer of the infection. The parasite entering the body of the tick with the blood of cattle may be already in the spore state or about to enter upon such a state. The young ticks, as they are hatched near the dead body of the female, may become infected from this. This infection, clinging to their mouth parts, is introduced into the blood of the cattle to which they subsequently attach themselves. Further investigations are necessary before the probable truth of one or the

* See page 112.

other of these hypotheses can be predicated with any degree of certainty.

It should be stated that the contents of the bodies of ticks in various stages of growth have been examined microscopically with considerable care. The abundant particles resulting from the breaking up of the ingested blood corpuscles obscured the search so that nothing definite has thus far resulted from it. The very minute size of the microörganism renders its identification well-nigh impossible, and any attempts will be fraught with great difficulties.

A question of much interest, but one upon which we have no information, is the relation of the cattle tick to the enzoötic Texas fever area. Is the distribution of the tick coextensive with that of the Texas fever micro-parasite, or does their distribution obey different laws? This question could be solved by a thorough investigation of a small portion of the border line of the enzoötic territory. This border line probably depends on the mean annual temperature, and hence we can not expect to find it very sharply defined. Ticks may extend farther north during some seasons than others, and hence there may be a belt or strip on which cattle are partially insusceptible because of former repeated attacks, although for the time being ticks may be absent. The entire subject is at present speculative, and is simply referred to here to arouse the attention of those who are in a position to record observations concerning it.

THE RELATION OF SOUTHERN CATTLE TO THE TEXAS-FEVER INFECTION.

What has already been said concerning the tick makes it certain that all Southern cattle are dangerous when they bear the cattle tick, whether they are sick or healthy. On the experiment-station fields, the North Carolina and Texan cattle which called forth Texas fever during the four years of the investigation were, in general, healthy. Two cows (Nos. 63 and 112) were killed. One of these had impoverished blood, although positive signs of Texas fever were not detected. Another died of peritonitis. The remainder were healthy, improved on the pastures, and were sold at the beginning of winter or before.

In the foregoing pages it has been assumed that the tick obtains the micro-parasite from Southern cattle. Without demonstration it might be claimed with equal propriety that the micro-parasite belongs essentially to the cattle tick, and that its multiplication in the body of susceptible cattle is perhaps an accidental phenomenon against which southern cattle have been amply protected by frequent infection. Experiments made latterly, as well as the microscopic examination of the blood, prove that the micro-parasite is harbored by Southern cattle in a state of health. These interesting experiments, as far as they have been carried up to the present, are briefly summarized here. The complete record will be found in the appendix under each case.

*Inoculation with blood of healthy North Carolina cows soon after the latter had left the Southern pasture.**—On July 6, 1892, a native cow, No. 198, received into a jugular vein 28 cc. of blood drawn from a jugular vein of a North Carolina cow, No. 217. The quantity of blood injected was large, because it was supposed that if the microörganisms were present at all in the Southern cattle they would be very scarce. The blood was drawn from the Southern cow by piercing the wall of the vein with the needle of a previously sterilized and warmed hypodermic syringe holding 14 cc., and injected immediately after into the exposed jugular of the native cow by simply piercing the wall of the vein. The entire operation lasted about two minutes. The high temperature became continuous on the seventh day after inoculation, and the number of red blood corpuscles had begun to fall on this same day. The various symptoms of Texas fever became gradually intensified, and the animal died July 19, thirteen days after inoculation. On the day before death the urine was claret-colored. The autopsy revealed the usual lesions of Texas fever.

On the same day No. 206, another native cow, was inoculated in the same way with blood drawn from a jugular vein of North Carolina cow No. 216. The same quantity, 28 cc., was injected as before, 14 cc. being injected at a time. The high temperature and the destruction of red blood corpuscles set in at the same time with those of the preceding case. This animal did not die, however. After passing through a prolonged fever period the animal slowly recovered, to suffer a relapse, which kept the number of red corpuscles below 2,000,000 during the whole of September.

On July 16, ten days after the preceding inoculations, a third cow, No. 219, received the same quantity of blood into a jugular vein. The blood was drawn from North Carolina cow No. 216. The continuous high temperature began July 24, at which date the destruction of corpuscles had set in. The further history of this case is very similar to that of the preceding, No. 206. The blood corpuscles continued to decrease in number until August 6. After this there was a slow rise. At the end of August a relapse was detected, which continued throughout September.

Inoculation with blood of healthy North Carolina cattle sometime after the latter had left the Southern pasture.—On August 15, a steer, No. 222, received 28 cc. of blood drawn from North Carolina cow No. 214. The same procedure as above was adopted. The disease had become established by August 25, as is shown by the high temperature and the marked reduction in the number of red corpuscles on this day. The movement of the disease was markedly slower, so far as this latter phenomenon is concerned. In the middle of September a relapse was detected, which was still in progress at the beginning of the second week in October.

* For the examination of the blood of the Southern cattle see appendix under each case.

On September 9, a cow, No. 230, received the same quantity of blood from No. 214 into a jugular vein. In this case the first high temperature appeared September 14, and by October 1 the number of red corpuscles had fallen to 2.2 million.

These positive results demonstrate that the Texas fever microörganism was present in the blood of North Carolina cattle as long as seventy-four days after they had left the permanently infected territory. One cow, No. 217, was tested once on the ninth day; another, No. 216, was tested on the ninth and the twentieth day; a third was tested on the forty-ninth and the seventy-fourth day. That the microörganism was the one found in natives infected in the ordinary way on pastures was demonstrated in every one of the five cases by a large number of microscopic examinations. No difference whatever could be detected. Moreover, three out of the five inoculated cases passed through relapses or mild secondary attacks, in which the stage of the peripheral coccus-like body appeared constantly in the blood, as in the ordinary mild type of the disease. There can be no doubt, therefore, that the micro-parasite transmitted in the blood of Southern cattle was the same as the one introduced into the blood of natives by the cattle tick.

It might be claimed that the Southern cattle harbored this micro-parasite because they are being constantly reinfected by the cattle tick. This might be true of Nos. 216 and 217, but it does not hold for No. 214. This animal was one of the four from which the ticks had been carefully picked in July, so that at the date of the last inoculation with blood from this animal it must have been entirely free from ticks for at least fifty days, and it had received no fresh accession of ticks since leaving its native pasture, June 27 (seventy-four days).

Whether the Texas fever parasite resides permanently in the bodies of Southern cattle or whether its presence, after all, depends on that of the cattle tick, these experiments do not permit us to decide definitely at present.* From an economic standpoint this is of little importance, since in many parts of the permanently infected territory of the South ticks are present during the entire year.

The presence of the parasite in Southern cattle does not seem to materially affect their health, although it may maintain a more or less constant breaking up of the red corpuscles on a small scale, which would necessarily tax certain vital organs. The parasite is present in the circulating blood in such small numbers, however, that only after a most

* The production of disease in 1891 by ticks which wintered over on one of the fields of the station would at first sight suggest the inference that the cattle tick carried the parasite through the winter in the egg. (*See* p. 90 and No. 154.) This does not follow from the circumstances, however, for there were in the same inclosure Southern cattle which had been kept over one or two years for purposes of reëxposure. Ticks hatched in spring may have invaded all the cattle in the inclosure, matured and dropped off, and given rise to another generation, which produced the disease late in August. This second generation may have obtained the micro-parasite from the Southern cattle.

tedious microscopic examination is it occasionally encountered. The fact that Southern cattle rid themselves of infectious properties on Northern pastures after twenty-five to thirty days does not, therefore, imply that their blood is no longer infectious. It simply signifies that they have rid themselves of the means by which this parasite is transmitted, namely, the cattle tick.

In this connection the reader may be referred to the various Southern animals whose blood was examined at one time or another during these investigations. Thus, in the Appendix, estimates will be found of the number of red blood corpuscles of Nos. 121, 123, 124, 126, 216, and 217, obtained at intervals after their removal from southern pastures varying from two to ten weeks. The number was, in general, fully up to the level maintained by the natives used in the experiments. There are, also, records of a few southern animals kept on the station grounds for longer periods, and subsequently exposed to Texas fever infection fresh from the South. Thus, No. 117 exposed, in winter, five months after arrival from the South, Nos. 32, 62, and 59 exposed one year thereafter, and Nos. 55 and 60 two years thereafter, show the normal number of red corpuscles.

The discussion which has raged so persistently about the health of Southern cattle has outlived its usefulness or suggestiveness, for it does not matter in what condition they are. So far as our evidence goes—and this is very strong—they are quite harmless, provided they do not carry the cattle tick. Hence there is no necessity for going into a review of the statements of Gamgee, the Metropolitan Board, and of F. S. Billings on this point. It is not claimed that Southern cattle may not and do not contract Texas fever. It is highly probable that every Southern calf has to go through the process of natural inoculation and reinoculation to a greater or less extent, and we have the records of several calves of Southern parents (Nos. 86 and 87) which passed through a mild form of the disease. It is likewise probable that a certain percentage of Southern animals which have not been sufficiently exposed while young may contract Texas fever in adult life under abnormal conditions. It is not impossible that under the influence of prolonged marches, crowding in cattle cars and on vessels, with insufficient air and food, the natural resistance of the body may break down and the mild or unobserved infection break out into an acute disease. These are possibilities as yet unproved, but they are by no means ignored when we state that Southern cattle, to all appearances healthy, do transmit Texas fever, and it is not necessary that they have any symptoms of disease, recognizable by clinical methods, to make them dangerous. We do not now wish to enter into any philosophical discussion as to what constitutes disease. From a practical economic standpoint we must maintain that Southern cattle may be healthy and yet be the cause of Texas fever.

The various hypotheses which observers have framed concerning the

infectious character of the excreta of cattle, the saliva hypothesis of Detmers, the manure hypothesis of Billings, or the urine hypothesis of others must now be considered as unfounded so far as these excreta are claimed to be the direct source of the disease, since the excreta of Southern cattle on Northern fields can not produce Texas fever. In those experiments (p. 111) which demonstrate that Southern cattle may pasture with susceptible Northern cattle throughout the summer without imparting disease, provided all ticks be removed, we have all the necessary proof for refuting these hypotheses, since the excreta and secretions of all kinds are left on the field. The only object missing is the cattle tick.

SICK NATIVES AS SOURCES OF INFECTION WHEN THE CATTLE TICK IS PRESENT.

This matter has called forth much discussion by scientific observers as well as by cattle-owners. It is a question of considerable importance to determine whether cattle which have contracted Texas fever in the ordinary way may transmit it to other natives coming in contact with them. That such transmission must be very rare is evident, otherwise there would have been no discussion and no divergent opinions. It is certainly a very curious fact that animals, which are affected with an infectious disease contracted indirectly through the presence of certain presumably healthy cattle, should not also transmit the same disease to other susceptible cattle. Theoretically, there is nothing opposed to the view that sick natives may infect other natives, and we shall show that they actually do so; but the conditions under which this infection takes place are rarely realized, and hence very little disease due to natives comes under observation. The fact that the disease may be transmitted from sick to healthy natives directly by injections of blood into the veins does not help us in solving the problem before us, since the disease is not conveyed in this way. If we turn, however, to the life history of the tick we shall find the explanation sought.

Sick natives have ticks on them. But only those which survive the disease or die after a prolonged attack ripen the tick on their bodies. Those which die of an acute attack in a short time after infection have only immature ticks on them. If the fever has occurred early enough in the season to permit a second generation of ticks to appear before the cold weather arrives, we may expect Texas fever on fields on which sick natives only have pastured. Usually the first outbreak occurs in August, and the second, to be looked for in late September or early October, is so mild as to pass unobserved. If, however, the first outbreak occurs in July, the second may appear in September and perhaps be of greater virulence.

In order to test this problem the following experiment was carried out:

In 1890 Field IV (see Fig. 5, p. 99) was set aside to be infected with sick natives only. The following sick animals were introduced:

August 21.—No. 49 and calf No. 85 exposed in Field VI since July 4; elevated temperature since August 19.

August 21.—No. 105, exposed in Field VIII (ticks only) July 4; elevated temperature since August 13.

September 3.—No. 50, exposed in Field VI July 4; elevated temperature since August 27.

September 5.—No 47, exposed in Field VIII (ticks only) August 21; elevated temperature since September 1.

September 8.—No. 135, exposed in Field VIII (ticks only) August 21; elevated temperature since August 30.

From the notes of the appendix it will be seen that all these cases excepting the calf went through a severe attack of Texas fever, to which No. 47 and No. 50 succumbed. The field was therefore infected, so far as this was possible, by sick natives.

In this field were placed two natives (Nos. 132, 133) on August 21. These animals passed through a mild but undoubted attack of Texas fever. In both, blood parasites were observed early in October, and the number of red corpuscles shows evidence of infection after the middle of September. Though this experiment is sufficient to demonstrate the ability of sick natives to infect pastures, a much more obvious and striking result might be obtained by an early infection of the fields.*

There are several instances reported of the transmission of disease by sick natives. The Metropolitan Board of New York City reported an outbreak of Texas fever among cattle at Hamptonburg, Orange County, N. Y. (1, p. 954), due to the importation of native cows from Painesville, Ohio, on the Lake Shore Railroad, over which a large number of Texas cattle had been passing. The disease, supposed to have been introduced by the Ohio natives, broke out in October, 1868, and deaths occurred as late as October 24 and 27. The cows brought from Ohio were received August 25, and deaths occurred among them on that day and up to September 10. It is also stated that several native cows died of Texas fever fourteen, sixteen, and nineteen days after exposure to these infected natives. This last statement is open to question, for if our deductions be correct and the general experience of those who have observed Texas fever be trustworthy, it would take from one and a half to two months for such infection to take place.

A very good illustration of the infecting power of diseased natives is that given by F. S. Billings (8, p. 41). According to his statement 1,100 Texan cattle reached Tekamah, Nebr., March 30–31, 1887.

* A similar experiment (p. 105) in the artificially heated stable with the progeny of ticks matured on sick natives is not conclusive on this point.

Twenty-one native cows put into one of the infected pastures May 1 began to die early in July. On June 19, twenty-four native steers broke into a pasture infected April 1–15 by the Texan cattle. They were returned next day to a pasture containing 114 natives. The twenty-four steers began to show signs of disease July 9, and only two recovered. Curiously enough Texas fever broke out among the 114 natives, and several were found dead September 21. These circumstances are all perfectly intelligible, if we apply the facts which we have worked out concerning the life history of the cattle tick and its relation to Texas fever. It is to be regretted that Billings did not make any observations on the ticks present on the infected cattle.

We will take it for granted that the Texan cattle brought cattle ticks with them, and that ripe females dropped on the pastures about Tekamah, Nebr., from April 1 to April 15. We have received such from North Carolina in midwinter which, confined in a paper box in the laboratory, promptly laid a large number of eggs. It might be claimed that at this date the low temperature would destroy the ticks entirely. It is true that low temperatures interfere with the growth of ticks on cattle and with the development of the young tick in the egg, but the embryo is not destroyed and simply lies dormant until the warmer season approaches. Thus on the experiment station ticks (probably in the egg) actually wintered over on a wooded pasture in 1890–'91. We are indebted to the Weather Bureau for the daily maximum and minimum temperature of De Soto, Nebr., about 25 miles south of Tekamah, from March 30 to May 15, 1887. From this table we learn that the thermometer fell at night below 32° F. only seven times after March 30, and that on April 8 the maximum temperature was 92° F. There was nothing in the weather, therefore, to prevent the ripe ticks laying their eggs. The young ticks probably did not hatch before the middle of June, because the twenty-one native cows which were put on an infected pasture did not begin to die until early in July. The twenty-four steers which broke into an infected pasture June 19 began to show signs of disease at about the same time (July 9). This short period of twenty days indicates that the ticks were probably just hatched when these steers broke in.

The time of infection of the large lot of natives by these steers may be easily calculated. They returned from the infected pastures June 20 with young ticks on them. If we allow twenty to twenty-five days for maturing, seven to ten days for egg-laying, twenty days for hatching, ten to fifteen days for the appearance of the fever, and seven to fourteen days for the first fatal case, we have in all sixty-four to eighty-four days from June 20 for the first death among the natives infected by natives. This could bring us to August 23 or September 12 as the probable date of the appearance of the disease originating from ticks which matured on native cattle. The actual date was September 21. Or we

may calculate it in another way. When Southern cattle infect the ground by simply passing over it, they do so by dropping ripe ticks ready to lay their eggs. In such a case we usually find a period of fifty-five to sixty days elapse before the first death. In the case before us the twenty-four steers which broke into the infected pasture June 19 brought only young ticks with them. Hence to the usual period of fifty-five to sixty days we must add twenty to twenty-five days to allow the ticks on the native steers to ripen. This would make the period seventy-five to eighty-five days and the first death might occur between September 3 and September 13, provided the case were acute and rapidly fatal, as is the case in midsummer.

The mortality of such secondary outbreaks due to sick natives is probably very low. In the case before us we are not told definitely by Billings how many of the 114 head exposed to sick natives succumbed, excepting that several were dead on a certain date. It has already been stated that only those natives which survive or die after prolonged illness can mature ticks on their bodies. Hence where the mortality is very high, the ticks may mature in but small numbers, so that the secondary outbreak due to sick natives may be mild for this reason as well as on account of the advanced season; for there seems to be, up to a certain point, a more or less direct relation between the number of ticks which attack cattle and the severity of the disease.

In regard to the infectious character of sick natives it may be concluded that the infection really exists and it may be transmitted to other natives by the cattle tick. The severity of the secondary disease will depend upon the time of the first outbreak among the natives and upon the number of ticks matured. It is as a whole not a very serious element and the losses result mainly from the impoverished condition of the animals which pass through such attacks.

SICK NATIVES ARE HARMLESS WHEN THE CATTLE TICK IS ABSENT.

This investigation is largely of theoretical interest in confirming the experiments which demonstrate that Texas fever is not transmitted from Southern to Northern stock without the intermediation of the cattle tick. Natives are not supposed to be sick excepting as they are infected by the cattle tick, hence the existence of sick natives without ticks must be of such rare occurrence that it is of no practical importance. In the following experiment the disease was produced in native cattle by the intravenous injection of blood drawn from the jugular vein of healthy Southern cattle. For a more complete discussion of these inoculations the reader is referred to page 119 and to the history of the individual cases mentioned below in the appendix. Here we simply mention the fact that the disease was actually produced and

that two natives, placed with such cases as controls, remained well, as is indicated in the annexed table:

Date.	No.	Quantity of blood injected into vein.	Source of blood.	Remarks.
1892.				
July 6	198	28 cc.	N. C. cow, 217.	Disease begins July 13. Cow dead July 19.
July 6	206	28 cc.	N. C. cow, 216.	Disease begins July 13. Acute attack followed by relapse in September. Recovery.
July 16	219	28 cc.	N. C. cow, 216.	Disease begins July 13. Acute attack followed by relapse in September. Recovery.
Aug. 15	222	28 cc.	N. C. cow, 214.	Disease begins August 18. Recovery.
Sept. 9	230	28 cc.	N. C. cow, 214.	Disease begins September 14. Recovery.
July 16	218			October 1, exposure negative.
Aug. 15	221			October 1, exposure negative.

The disease began in this field as early as July 13. Five animals had passed through the disease and one had died on it. The control No. 218 had been in it from July 16, *i. e.*, 77 days up to October 1 without manifesting the slightest signs of infection. The second control spent 46 days in this inclos ure up to October 1, with the same negative outcome.

MAY TEXAS FEVER BE COMMUNICATED BY AGENCIES OTHER THAN THE CATTLE TICK?

We have seen in the foregoing pages that the transmission of Texas cattle fever may be prevented entirely by removing the ticks from Southern cattle in such a way that a new generation is suppressed. We have likewise seen that sick natives may remain in the same inclosure with healthy natives for months without transmitting the disease to them, provided the sick natives have no ticks on them, or, in other words, provided the disease has been produced by direct inoculation. These facts go far toward bringing us to the conclusion that no outbreaks of Texas fever are produced without ticks. Yet we can not deny the possibility of a conveyance of the disease by other agencies, for this possibility is demonstrated by the fact that by a direct transferrence of blood from sick natives, and even from healthy Southern animals, the disease may be reproduced with all its characteristic virulence. We know as yet so little of the ectogenic life of the Texas fever parasite that whatever hypotheses may be made must remain such until our knowledge has become more defined. Meanwhile we may formulate certain possibilities of transmission without the aid of the cattle tick to call the attention of future observers to them.

It is possible that the disease may be conveyed by insects, which pierce the skin and draw blood. Such pests, when moving from sick to healthy animals very rapidly, may carry enough blood on their mouth parts to inoculate healthy animals. But under such circum-

stances several factors come into play, such as the probable destruction of the micro-parasite by drying and other unknown agencies, and the probability that the quantity of blood is too small to contain any parasites. Moreover, a single parasite, or even a few parasites, may not produce anything more than a mild, unnoticed affection. The possibility of direct inoculation by insects may depend on the distribution of insects which draw blood. In the District of Columbia Texas fever was not carried by insects, with the possible exception of a single instance, to be described below, during the four summers of work from 1889 to 1892, inclusive, although the very best opportunities were offered them to carry on direct inoculation, especially during the present summer. There may be parts of our country, however, where such direct inoculation from sick to healthy natives in midsummer is favored by the presence of certain insects not to be found near Washington.

If we consider for a moment the probability of an infection of native from Southern cattle directly by means of flies, etc., we shall find it very slight. Though we now know that Texas fever parasites exist in the blood of presumably healthy Southern animals, we must regard these parasites so scarce in number, if we are to be guided by the microscopic examinations of the blood, that insects can not draw enough blood to become dangerous. The infection of natives by Southern animals in this way must be considered probable only when authentic cases of this disease are on record which appeared ten or fifteen days after contact with Southern cattle, *provided the ground has not been previously infected with ticks from other Southern herds.* There seems to be no carefully investigated outbreak of Texas fever on record which occurred within thirty days of the ground infection or of contact with Southern animals.

In case Southern droves of cattle contain animals actually diseased with Texas fever, their blood would contain more parasites than that of the healthy, and hence might serve more readily as an inoculating fluid for insects, but Southern animals and natives are not allowed to mingle so as to bring this about. The disease is produced, in most cases, where Southern and native cattle do not come in contact at all. If insects distribute Texas fever they could only do it accidentally, and hence the result would be a few isolated cases. But Texas fever attacks 90 to 95 per cent of all natives.

Texas fever, as elucidated in the foregoing pages, is essentially a disease of the blood. The parasite producing it must be transferred in some manner from the blood of one animal to that of another. There is no evidence to support the view that it may gain entrance by way of the digestive tract, and hence several channels by which the micro-parasite might get into the body are necessarily cut off. Though the parasite is very likely present in the discharges and the urine of the sick, and perhaps in smaller numbers in the excretions of Southern

animals, yet pastures infected by such excretions are not infectious. In 1890 the following experiment was made :

Blood and spleen pulp from several natives which had succumbed to Texas fever was scattered over the ground in Inclosure V, and two natives (Nos. 109 and 136) pastured in it from August 25 to November. There was no trace of Texas fever discovered in either case, although the blood was examined at three different times. The number of blood corpuscles in one of these animals (No. 136) was below normal, but as it remained at this low point throughout the season, and as the animal had some vaginal discharge, the low number must have been due to disturbances of the generative organs. In the other animal the red corpuscles remained above 5.7 millions.

Perhaps the best evidence which can be adduced that the excretions do not have anything to do in transmitting the disease is the experiment in which healthy natives were exposed to sick natives free from ticks for months without any result.

The only exception, and this a doubtful one, to the general result of our experiments and experiences at the station, that Texas fever appears only with ticks on native cattle, occurred in 1891. Field XII (see Fig. 7, p. 108) was used only for the storing of unused healthy cattle during the course of the experiments of that summer. In this field a cow was kept (No. 168) upon which bleeding had been performed a number of times for the study of changes going on in the blood in anæmic conditions. The examination of the blood in this case began August 3 and was continued at intervals to September 8. The animal was led out of the field during each examination to a box, into which she was fastened during the venesection and the collection of the blood. On September 1 No. 162 was received and placed in this field. On September 26 she was observed to be dull and to refuse to eat. The temperature on September 28 was over 104° F. On the following day the animal was found dead. The autopsy revealed an acute case of Texas fever, with an enormous infection of the red corpuscles of the blood with the Texas-fever parasite. An examination of the other animals in this field showed that only one other was diseased. This was the case upon which venesection had been practiced and whose blood had been examined last on September 8. How was this infection brought about? In a preliminary report* the probability of direct inoculation by flies was emphasized. The disease had appeared on the station as early as August 8 in those cases artificially infected with young ticks, and it appeared subsequently in the general-control Field VI. Hence the opportunity was afforded for the conveyance of the virus by insects from sick animals. Instead of this channel of infection there is one other possible one. Though no ticks could be found on the animals in this field, a few may have been carried there in the course of the season, or they may have crawled there. A few

* Report of the Secretary of Agriculture for 1891, p. 134.

ticks on an animal may have been overlooked, since they are still quite small when animals succumb in the acute stage. Moreover, they may have attached themselves in places not regularly selected by the young ticks (inner aspect of thighs and escutcheon), in which case they would have been quite certainly overlooked. On the whole we must confess that the infection of these two animals is a matter the obscurity of which can not be cleared up. They are the only cases of Texas fever which have occurred on the station fields during the four summers of experimentation which are not directly traceable to Southern cattle carrying ticks, to ticks alone, or to direct transferrence of blood from sick native or healthy Southern animals to susceptible natives by inoculation.

IMMUNITY AND PROTECTIVE INOCULATION.—DISTRIBUTION OF DISEASES RESEMBLING TEXAS FEVER ON OTHER CONTINENTS.

IMMUNITY IN SOUTHERN CATTLE.

It has been stated by some observers that Southern cattle soon lose their immunity against Texas fever after they have been taken to Northern pastures, and that they are liable to be attacked by this disease after having been away from the permanently infected territory for a year or longer. These statements, so far as we know, are not based upon experimental evidence, but upon observation of natural outbreaks, and hence the evidence is likely to be weak in one or more points. As we were more or less favorably situated to test these statements, some of the Southern animals were kept on the station grounds for one or two winters and then reëxposed to freshly imported Southern animals together with Northern stock. These experiments are a part of those already described in connection with ticks, and the following numbers, therefore, belong to the original experiments.

Experiment 8 (*exposure of native to Texan cattle*, *page 100*).—In addition to the natives, a Southern animal (No. 62), brought from North Carolina in 1889, was exposed on this field September 25, 1890, with a native (No. 74). The latter died October 16, while the Southern animal appeared not to be affected. The blood was examined three times. The corpuscles did not fall below five and one-half millions. All adult natives exposed in this inclosure during the summer succumbed to Texas fever.

Experiment 9 (*exposure of natives to North Carolina cattle*, *page 100*).—In addition to the natives placed in this inclosure, the following North Carolina cattle of the previous year were introduced July 4, 1890:

No. 32 (heifer, 3 years). Exposure negative.
No. 59 (cow, 5 years). Exposure negative.
No. 87 (calf of No. 59, 3½ months). Slight infection.
No. 61 (steer, 2 years). Exposure negative.
No. 67 (cow, 5 years). Exposure negative.
No. 86 (calf of No. 67, 2 months). Slight infection.

From this table it will be seen in the first place that none of the cattle died or became visibly diseased. In Nos. 32 and 59 the blood was examined September 3, when all exposed natives were either sick or dead, and found normal. Nos. 61 and 67 were not examined in this way. In case of the two Southern calves descended from Southern

parents, but born on the station, there was a slight infection characterized by the presence of the intraglobular coccus-like stage of the Texas-fever parasite. In No. 87 these were detected September 20, but the blood corpuscles did not fall below five millions, as far as the few examinations are evidence. In No. 86, the younger calf, there was a decided fall in the number of red corpuscles associated with the presence of the parasite in the same stage as in No. 87. The corpuscles numbered but three and one-half millions October 30.

Experiment 14 (exposure of natives to North Carolina cattle, page 107).—In addition to the natives placed in this field the following Southern animals were introduced July 2, 1891:

No. 55 (cow, 5 years old, from North Carolina in 1889). Exposure negative.

No. 62 (heifer, 3 years old, from North Carolina in 1889, exposed in 1890). Exposure negative.

No. 121 (cow, 4 years old, from Texas in 1890). Exposure negative.

No. 126 (cow, 6 years old, from Texas in 1890). Exposure negative.

These four exposures proved negative (so far as any outward signs of disease are concerned). No. 55 had been away from Southern pastures and not reëxposed for two years. Her blood August 29 was normal. The blood of Nos. 62, 121, and 126 was not examined. In these experiments the examination of the blood was not carried on systematically, and hence no very definite conclusions can be drawn as to the presence or absence of all disease. However, the examination of the blood of adults when made was negative. It is evident that the immunity of Southern cattle is not lost in one year or in two years. And by this we mean insusceptibility so far as a severe attack is concerned, for none of the adults showed any signs of disease, while none of the exposed natives resisted.

It is especially interesting to note that the two Southern calves exposed for the first time were not entirely insusceptible. A mild form of the disease was detected late in the season, and it is not beyond probability to assume that they may have been slightly affected through the entire summer. This seems to make it probable that Southern animals acquire at least some of their immunity by mild attacks very early in life.

NATURAL IMMUNITY OF NORTHERN CATTLE.

Natural immunity of cattle more than 1 year old.—This we know is very slight, for the mortality in many outbreaks has been found to be nearly 100 per cent. Still, there are animals which have more or less immunity, though never exposed to the virus of this disease. By compiling the cases exposed on the station in the ordinary way to Southern cattle in 1889, 1890, and 1891 (experiments 1, 9, and 14), and rejecting all those exposed after September 15, we may obtain approximate percentage of insusceptible cattle. There were exposed in all during these three years 24 head over 1 year old. Of these only one animal

remained unaffected, though exposed twice. This was an old cow (No. 57). The remainder passed through more or less severe attacks and five (Nos. 49, 53, 56, 104, and 159) recovered. Some animals, it is true, were killed, but in a dying condition, and these are included with those that died. It may be said, therefore, that about 95 per cent of adult Northern animals are susceptible to Texas fever. When we examine the record of the animals under 1 year of age we obtain a somewhat different result.

There were exposed in the general fields in 1889 and 1890 in all eight calves. Of these two (Nos.10, 11) died in 1889 from an acute attack of Txas fever and two (Nos. 52 and 75) recovered. The remaining four (Nos. 79, 85, 93, and 100) exposed in 1890 were all affected, but none died of an acute attack. The disease was of the more or less mild, prolonged type, with the intraglobular coccus-like stage of the parasite in the blood.* Some succumbed at the beginning of winter from exhaustion, but not so far as could be discovered from the after effects of Texas fever. In general, calves are not insusceptible to Texas fever, but the disease is milder and the mortality is lower than with those more than 1 year old. Attention is here called to the case of No. 102_a, a calf, which was found dead thirteen days after birth in a field infected with ticks only (experiment 10). The lesions were unmistakably those of Texas fever.

ACQUIRED IMMUNITY OF NORTHERN CATTLE.

This is a problem of far more economic importance than those just discussed, since it affords us some insight into the possibilities of producing immunity artificially. The various field experiments of 1889, 1890, and 1891 furnished a number of animals, some of which had passed through a mild attack, others through an acute attack. Many of these were reëxposed the following year to freshly introduced North Carolina cattle in company with fresh native animals. The following summary includes all such exposures. The number of the experiment corresponds in every case to that already described, of which the one under consideration forms a part.

Experiment 9 (*see page 100*).—The following recovered cases of 1889 were exposed with fresh natives to North Carolina cattle:

July 4, 1890.—No. 51 (cow, 4 years) passed through a mild attack in the fall of 1889.

July 4, 1890.—No. 53 (cow, 2½ years) passed through a fairly severe attack in the fall of 1889.

July 4, 1890.—No. 64 (steer, 3 years) passed through a mild attack in the fall of 1889.

September 20, 1890.—No. 65 (cow, 3½ years) passed through a mild attack in the fall of 1889.

July 4, 1890.—No. 75 (heifer, 16 months) passed through a prolonged attack in the summer of 1889.

*It is probable that in all of these cases a short acute attack preceded the mild attack.

In these animals the severity of the first attack is best measured by the intensity of the destruction of red corpuscles. The number of corpuscles in No. 51 had fallen below 1.5 millions on November 4, 1889. In No. 53 they fell to 2.5 millions. In No. 64 they had fallen to 2.7 millions on November 7, but there were still many infected corpuscles in the circulation. In No. 65, they numbered only 1.7 millions November 4. No. 75 was not examined. The result of the second exposure in 1890 is, briefly, as follows:

No. 51 dies of an acute attack August 26.
No. 53 probably not affected.
No. 64 passes through a prolonged, but rather mild attack.
No. 65 passes through a mild attack (exposure late) and dies some time after.
No. 75 probably not affected.

Experiment 10 (*see page 103*).—No. 47 (cow, 4½ years) had passed through a rather severe attack in the fall of 1889. The red corpuscles at that time fell below one million. July 4, 1890, she was placed in Field VIII, into which only adult cattle ticks had been thrown. She died of an acute attack September 12.

Experiment 14 (*see page 107*).—The following recovered cases of 1890 were exposed with fresh natives to North Carolina cattle July 2, 1891:

No. 56 (steer, 4 years) passed through a prolonged attack in fall of 1890.

No. 102 (cow, 7 years) passed through an acute attack (due to ticks only) in summer of 1890.

No. 130 (cow, 6 years) passed through a rather severe attack (Experiment 13) in artificially heated stable (1890–'91).

No. 143 (heifer 2½ years) passed through a doubtful attack (Experiment 13) in artificially heated stable (1890–'91).

The result of this exposure is, in brief, as follows:

No. 56 passed through a mild attack.
No. 102 was slightly, if at all, affected.
No. 130 died from an acute attack August 27.
No. 143 passed through an acute attack and recovered.

Experiment 17 (*see page 111*).—In addition to the natives, not hitherto exposed, which were placed into Inclosure VI, in 1892, together with fresh North Carolina cattle and ticks, the following recovered cases were included:

No. 135 reëxposed July 20. This animal had passed through an attack in Field VIII (ticks only) in 1890. This summer it was again attacked, and the red corpuscles at one time were found as low as 2,000,000.

No. 167 was reëxposed on the same day with the preceding. It had passed through an acute attack last year, and was very low for a time. This summer there was probably a slight attack, as the blood corpuscles, though they did not fall below 5,000,000, showed signs of regeneration.

The following cases were reëxposed together on August 26, in the same field, and a hitherto unexposed native, a bull (No. 204), 2½ years old, was put in with them as a control, since the season was now somewhat advanced:

No. 56 had passed through a prolonged but mild attack in the fall of 1890. In 1891 it was again exposed and passed through a short, acute attack. This summer there was probably a very short attack, as is indicated by the record of the red corpuscles.

No. 105 had passed through an acute and prolonged fever in Field VIII (ticks only) in 1890, followed by a relapse later on in the same season. A second exposure in September of 1891 was apparently negative. This summer, however, the disease reappeared on exposure, the loss of red corpuscles being fairly severe.

No. 160 was exposed late in 1891 and passed through a short but acute attack, followed by a relapse which lasted into December. This summer the exposure was evidently negative.

No. 166 was infected with artificially hatched ticks in 1891, and passed through an acute and rather prolonged attack. This summer the exposure was negative.

No. 182 passed through an acute attack late last year as the result of the intravenous injection of infected blood. This year the exposure resulted in a slight attack.

No. 185 at the same time passed through a similar attack, due to inoculation. This summer the exposure was negative.

No. 204. The control exposed at the same time in this field passed through a very acute attack, and was probably saved by its age. No. 225, which had just passed through the disease due to an infection with artificially hatched ticks, and whose blood corpuscles had nearly reached the normal, was transferred to this field August 30, four days later than the preceding lot. A second attack was the result, with a rapid and extensive loss of corpuscles. This case is merely introduced to show the intensity of the infection still existing in this field, but it can not be wholly regarded in the light of a control.

The following table gives a brief résumé of these exposures:

Nature of attack.

No.	1890.	1891.	1892.
56	Mild, prolonged	Short, acute	Slight(?).
105	Acute, prolonged, with relapse	Negative	Fairly severe.
135	Acute		Do.
160		Short, acute, with relapse	Negative.
166		Acute, prolonged	Do.
167		Acute	Slight(?).
182		do	Mild, short.
185		do	Negative.
204 (Control.)			Very acute.

These experiments demonstrate the important fact that one attack of Texas fever does not necessarily protect the animal from a second attack. Of the eighteen cases seven may be said to have remained practically unaffected during the second exposure. Of the remaining eleven three died during the second exposure. It is impossible to determine in such cases how much natural immunity existed before the first attack. Thus No. 53 survived the first attack while another cow exposed at the same time and nearly of the same age succumbed to an acute attack. No. 75, the heifer which passed through the first exposure as a calf 4 months old, is hardly to be regarded as a fair case. Hence we must be cautious in giving even in these cases too much credit to the first attack in warding off the following one. It is not to be denied that in the case of animals not more than 2½ or 3 years old a first mild attack may prevent a second fatal attack in many cases, and a first acute attack may be followed by a very mild infection, but it may be laid down as a general proposition that a single attack is not sufficient to produce complete immunity.

PROBLEMS CONCERNING PREVENTIVE INOCULATION.

If a single attack of the disease itself does not afford complete protection it is not likely that any process or method of artificial inoculation will be successful in this respect. The profound effect which is necessarily produced in the body of an animal by a destruction of red corpuscles equal in amount to all those circulating in the body at any given time should make much more impression than any method of inoculation is likely to do. And yet such an attack not only does not prevent a second attack but may not prevent death during a second attack. Aside from the difficulties attending the production of insusceptibility under any circumstances the difficulties of preparing a "vaccine" according to the method hitherto practiced are at present insurmountable. The microörganism which we have described as the presumable cause can not be cultivated. Hence the method first practiced by Pasteur of using an attenuated form of the virus itself is not within reach and other means must be sought. Before suggesting any lines of experimentation in this field let us examine briefly under what conditions it is desirable to have an animal insusceptible to Texas fever.

On pastures north of the permanently infected area Texas fever can be kept away by properly applied preventive measures. Hence the protection of Northern cattle by some artificial process is unnecessary and practically out of the question. It is, however, of great importance to be able to protect from a fatal attack valuable animals which are to be taken South into permanently infected territories. It is probable that if calves be taken they may, without treatment of any kind, survive the infection upon Southern pastures and become gradually insusceptible. But in case of animals more than 12 to 18 months old the first attack might be fatal, and if a preliminary mild attack could be induced by artificial means the fatal effect of a second attack might be averted.

Perhaps the simplest manner of producing a mild, usually nonfatal attack is to expose cattle on pastures which have been infected with ripe, egg-laying ticks at some specified time in the fall. This time must depend on the climate of the locality where the infection is to be practiced. In the latitude of Washington we found in 1889 the middle of September a convenient time for the infection. In more northerly latitudes the exposure should be correspondingly earlier. Cattle exposed in this way take Texas fever invariably, but the mortality is practically zero. Such animals may die of a second attack during the succeeding summer, but a second mild exposure during the following autumn may furnish a sufficient protection. Inasmuch as the recovery from even severe attacks of Texas fever is usually complete and not followed by any permanent debility, such mild attacks would not be likely to cause any permanent injury to the exposed animals.

Another method of inducing Texas fever is the injection of blood

from cases of Texas fever. Such inoculations are apt to result in a mild attack if practiced after the hot weather of midsummer. The blood of Southern cattle will serve the same purpose, as our experiments carried on this year (1892) have shown. If practiced in early summer the injection of such blood induces a prolonged attack, and may cause death. (See Nos. 198, 206, 219, 222, and 230.) These latter methods of inoculation require either the presence of Texas fever or of freshly imported Southern cattle.* The former method of exposure to ticks is on the whole simpler, since it requires no operation, and since ticks are easily procurable from the permanently infected Southern territory. Mild attacks of this kind should be watched with care and the blood examined from time to time to obtain positive information concerning the severity of the induced attack. The temperature should likewise be taken morning and evening.

Efforts to protect Northern cattle by inoculation were made by Dr. Paul Paquin (9, p. 14). We can not review these experiments in detail. While we must commend the faithful work, we must dissent from the method, and hence can not regard it as applicable in practice. The wholly different outcome of our experiments concerning the micro-örganism and the cattle tick as probably the only transmitter prevents us from accepting any results based upon hypotheses which are now shown to be unfounded. But if we look at the results obtained by Paquin's vaccination we will be convinced that they are far from being satisfactory. Thus Dr. Dinwiddie (9, p. 23) reported a mortality of 100 per cent among nonvaccinated animals, and of 75 per cent among vaccinated animals exposed in Arkansas. Of vaccinated and nonvaccinated cattle sent to Texas 66⅔ per cent of the former and 88⅔ of the latter died. These percentages show so little difference between the mortality of vaccinated and nonvaccinated cattle that, bearing in mind the various unknown factors which come into play in such experiments, we may regard the effect of this mode of vaccination as negative. What is meant by the author when he speaks of the virus used in these inoculations as doubtful it is difficult to understand. A culture always contains a definite kind of bacteria and they are either of the wrong kind or the right kind, and no vaccination experiments should be attempted or, if attempted, reported without an exact description of the underlying conditions, so that they can be repeated if necessary by others. The real difficulty, however, with these experiments lies deeper. Vaccination experiments were tried before anything definite was known concerning the nature and causation of the disease, and hence were built on hypotheses of a vague character in place of demonstrated facts. Any reader of the foregoing pages of this report will be satisfied that the diagnosis of Texas fever must now require a careful

* Since the above was written we have determined that the Texas fever parasite was carried in the blood of a North Carolina animal 3 years after leaving the permanently infected territory.

periodical examination of the blood, and that unless this is carried out the disease may escape observation. Again all test exposures must be made under precisely the same conditions and not in different inclosures with a doubtful or a variable infection, since we now know that the infection is carried by the newly hatched tick.

The statements made above concerning the possible uses of mild infections as means of subsequent protection must be regarded as mere suggestions which may or may not prove of practical utility on a large scale. They are carried out so easily, however, that they may be tried by anyone exercising a certain amount of care.

IS TEXAS CATTLE FEVER RESTRICTED TO THE AMERICAN CONTINENT?

Among the diseases carried from their natural habitat by intercourse Texas fever occupies a very prominent position. Existing chiefly as a mild, rarely recognizable, malarial infection in certain regions of our country, it becomes a highly fatal infectious disease when transported beyond its natural confines. The movement of cattle is entirely responsible for the phenomenon. The question naturally presents itself whether such a disease is not to be found in other countries situated as we are. Only an active movement of cattle, such as took place in our country in 1867 and 1868, in the hot months of the year, together with their dissemination over Northern pastures, would demonstrate the presence or absence of such a plague on other continents. But there is evidence even now that a disease resembling Texas fever very closely, if not actually identical with it, exists in southern Africa and in Europe along the Danube.

SOUTH AFRICA.

In 1883 a report was presented to the English Parliament by a commission of inquiry concerning a disease among cattle in the colony of the Cape of Good Hope known as "redwater." This disease is defined by the commission as—

> an infective and malignant fever in horned cattle, characterized by the passing of urine of a color varying from blood-red to purplish-red, and holding the hæmatin or coloring matter of the blood in solution. One ox can not give another red-water as a smallpox patient can give his disease to his neighbor. Redwater is not contagious in that way. The poison of redwater passes from a suffering animal on to pasturage. What, if anything, happens to the poison at this stage is not fully determined. Another ox feeds over the pasturage thus contaminated and becomes in his turn the sufferer.*

The disease was first observed in 1870. Since then it has been introduced from time to time by oxen used as carriers which keep up communication with the territory north of the colony. Of the precise manner in which the virus is communicated by the cattle only this was known, that while they did not infect other cattle directly they did infect the ground over which they passed.

* Supplementary report (1884), p. 3.

The symptoms of this disease are summarized by the commission as follows:

The beast, when first observed, appears dull and sluggish, with a tendency to leave the rest of the herd; the hair stands erect, like that of an animal on a cold day (a staring coat); the ears hang, and the eyes have a dull, lusterless appearance. In some cases the beasts will cease feeding; in other cases they continue to nibble at the herbage until nearly the last, but in an indifferent manner, indicating that they have no relish for their food. There is generally a dribbling of saliva from the mouth, the nose or muzzle may appear quite moist during the early stages of the disease, but it invariably becomes dry and crusty as the disease advances. Later on, the animal will manifest a disinclination to move, and when compelled to do so, will walk with a dragging, straddling gait, as if weak across the loins. In some cases where the sick beast is left undisturbed, it will remain almost constantly in one place, and while standing with head depressed, and ears hanging, in a drowsy, semi-comatose condition, look the very picture of complete nervous prostration. Some such cases will lie down the greater part of the time and scarcely move, and when found dead the head and limbs will be resting in their natural position, as if the beast was asleep. In one very marked case of this kind the colonial veterinary surgeon, on making a post-mortem examination, found the carcass pale and almost bloodless, as if the animal had been bled to death. In other severe cases a twitching and quivering of the muscles will be observed, especially of those situated in the flank and behind the shoulder, while the animal will stand and grind its teeth and curl up its upper lip. The beast's dung during the early stages of the disease is very often soft, with a tendency to diarrhœa in some cases; but it almost invariably becomes hard as the disease advances. In some very severe cases, where recovery has taken place, the favorable crisis appeared to be ushered in by a salutary diarrhœa. But whether the dung is hard or soft it is generally of a brownish tinge, and mixed with blood and mucus. In milch cows the very first symptom observable, is the sudden cessation of milk; and in many mild cases, of which there is generally a considerable percentage in a herd, the only symptoms discernible are a dull, dejected appearance, staring coat, and a slight stiffness for a day or two, after which these symptoms disappear, and the animals resume their usual appearance. Of course, the most prominent and diagnostic symptom in this disease is the color and the character of the urine, which varies generally as the disease advances from a pale yellow to a dark port-wine color, in many very typical cases, however, even amongst those which terminate fatally, the urine does not acquire that deep tinge. In many cases, also, even when the attack has been very severe, when the crisis is passed, recovery is very rapid, and it is very remarkable, in such cases, how soon the urine reassumes its normal color and density with the disappearance of the albumen. In other cases, again, where the liver fails to resume its healthy function, the beast will become hidebound and unthrifty-looking, while a thick scurf will form on the skin.

The lesions observed on post-mortem examinations were reported by the veterinary surgeon of the colony as follows:

On cutting through the skin the flesh is seen to be pale and bloodless, and occasionally of a yellowish tinge; sometimes there is subcutaneous emphysema and infiltration of yellowish-colored serum. * * *

Liver.—This organ is nearly always more or less affected, being augmented in volume, and in many instances altered in texture, and so softened as to be easily broken up with the finger. On cutting into it the ducts are often found filled with bile, and sometimes from the cut surfaces large quantities of black blood escapes. The gall bladder is usually full of thick bile, and many have thought that this distended condition of it was in some way the cause of the disease, which is quite a mistaken notion, as this state may be observed in other diseases, and in any case where the

process of digestion is arrested, as the bile continues to be secreted and simply collects in its natural receptacle till wanted for use.

Spleen.—This viscus I have invariably found affected, it being generally enlarged to three or four times its natural size, and filled with black blood, giving to its external surface a livid blue or black color. On holding it up by one end, it will be found that the blood will gravitate to the most dependent part, showing that the splenic tissue is disintegrated. On cutting into it, black incoagulable blood escapes from the incision.

Kidneys.—In a few instances I have found these organs looking quite natural, but, as a rule, they are much congested, dark in color, and augmented in volume, and sometimes easily broken down.

During the outbreak of this disease in 1871–'72, many persons noticed engorgement or discoloration of the tissues surrounding the kidneys, while the capsules of the kidneys contained a fluid more or less dark colored.

Bladder.—This usually contains urine of a high color, often quite black, but sometimes not much altered in appearance. If left to stand it deposits a sediment, which on examination is found to consist of mucus corpuscles, hippurates, etc., while the urine itself contains a variable quantity of albumen.

The color I find due to the escape of the hematin of the blood.

Mouth.—On the tongue I have sometimes seen dark-colored spots or patches, but this condition is by no means constant, as in many instances the mouth looks quite healthy.

Rumen.—In this stomach I have found the inner coat much discolored after the animal has been dead some hours, the epithelium peeling off readily. In other cases when I have opened animals immediately after death, I have not found this condition, though in a few instances I have noticed a slight redness.

Reticulum.—This stomach has not exhibited any symptoms of disease in any animal that I have examined.

Omasum (third stomach).—In most cases I have found this organ healthy; sometimes I have noticed the leaves slightly reddened, and the vessels radiating from their attached border injected, but I have never observed the sloughing which occurs in cases of rinderpest, and some other diseases, nor ecchymosis either. When I have found the tissues discolored and the epithelium peeling off readily, it has been after the animal has been dead some time, and the same occurs in cattle which have died from other causes. In a few instances I found the contents hard and dry, in others quite soft.

This dry, impacted state is not peculiar to this disease, nor has it anything to do with the cause of it, as some have supposed.

Abomasum (fourth stomach).—I have noticed intense congestion of this organ in all cases, with more or less ulceration penetrating to the muscular coat. In some instances there were superficial erosions not extending to the submucous tissue.

The mucous membrane was covered with mucus generally tinged with blood.

Intestines.—The small intestines are invariably congested, and in other respects present the same appearance as the fourth stomach. Peyer's glands I have found enlarged and dark in color, but I have not detected ulceration of them.

The large intestines present a similar appearance to the small, but in a lesser degree.

In a few instances a kind of croupous exudation has been seen, and casts of portions of the intestines have passed with the feces.

Chest.—In this cavity I have not observed any particular indication of disease, with the exception of patches of ecchymosis in the lining membrane of the heart.

Brain.—In the few instances where I have examined the brain I have found the membranes covering it much injected and yellowish colored serum in the ventricles.

Enough of the report has been quoted to illustrate the striking sim-

ilarity of this South African disease and Texas cattle fever as regards the symptoms and lesions and the noncontagious character of both maladies. Both are carried by cattle from warmer, permanently infected territories, and in both the pastures become infected. In fact, the Commission reports that a certain line exists which represents the boundary of the infected district. This is deducible from the minutes of the proceedings, where the following passage occurs:

The Commission recommend that the southern Redwater line, at present drawn at the Umtata River, be strictly respected, and that no cattle, either loose or in yoke, be allowed to cross that line except from a portion of East Pondoland, where no Redwater is known to exist, and from such portion of East Pondoland only by certificate.

It is to be hoped that this peculiar disease will be soon made the subject of investigation to determine whether or not it also is transmitted by some specific parasite like the cattle tick, and whether or not it is really the same as Texas fever.

ROUMANIA.

Still better evidence of the existence of Texas cattle fever outside of our own country is furnished by certain investigations made by Prof. Victor Babes,* of Bucharest, in 1888, concerning epizoötic hæmoglobinuria among cattle in Roumania. According to Babes—

A peculiar disease devastates, since olden times, the herds of Roumania. Native veterinarians have given it the name gastro-entero-nephritis. Nowhere are references to be found in publications concerning this plague, which formerly was regarded the same as rinderpest. It is not less fearful than the latter in the persistence with which it demands annually thousands of victims from among the most powerful draft oxen, especially in the swampy lowlands of the Danube River. * * * Government commissions had endeavored to determine the nature of the plague in former epizoötics, but neither the infectious nor the contagious character could be determined. The disease was looked upon as a kind of malarial disease.

Its dissemination seems to be largely due to draft oxen. Babes is inclined to consider it as spreading from public drinking places, and that the infection starts from such fountains as centers and extends over a restricted area therefrom. Babes also makes the curious statement that "the disease moves from one end of the village to the other, reaches after a few days a certain place in the village from which it does not spread farther, while those animals in the infected part of the village hitherto spared from the disease may succumb later." It is evident that the way in which the virus is disseminated is not known, and that the above statements are more or less contradictory and need elucidation. It should be borne in mind that the conditions as described by Babes must be very complicated, owing to the employment of draft oxen moving from place to place. No mention is made in these investigations of any ecto-parasites.

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*Die Aetiologie der seuchenhaften Hämoglobinurie des Rindes. Archiv. für pathol. Anatomie und Physiologie, CVX, (Jan., 1889), p. 81.

Symptoms.—The most powerful draft oxen are the chief victims. Cows are rarely attacked; calves never. An animal affected with the disease appears weak, the head and ears droop and the back is arched. The temperature is elevated, the pulse and respiration rapid. After two days some recover, others begin to pass dark-red urine. In such cases emaciation becomes marked, muscular tremors appear, and the temperature rises to 40–41° C. (104°–105.8° F.). The animal now sways and drags its hind limbs after it. The bowels may be constipated or pass liquid, reddish-brown, sometimes bloody stools. The disease may terminate fatally in four to seven days. In rare cases fatal relapses occur after apparent recovery. The urine contains but rarely red corpuscles. Usually albumin and coloring matter of the blood are present.

Pathological changes.—The lesions found by Babes are intermingled with those produced by *Pentastomum*, so that it is difficult to determine which are due to the specific fever and which to the parasites. Of the more important we may extract the following brief statements:

The lungs may be the seat of emphysema and hyperæmia. The heart muscle is pale red, friable. The fluid blood and the clots in the heart cavities are quite pale, indicating a marked loss of coloring matter. The liver is enlarged, in some cases yellowish brown, in others dark brown and rich in blood. Babes dwells upon the peculiar mottled appearance of stained liver sections due to the fact that the central zone of each acinus is in a necrotic condition; *i. e.*, the nuclei have wholly or partly disappeared from the parenchyma cells. This condition is precisely similar to that observed in Texas fever. The gall ducts are not obstructed. The gall bladder contains fluid, orange-yellow bile.

The spleen is always enlarged, black or blackish red, the capsule tense. The enlargement resides in the pulp, which is blackish, disintegrated.

The third stomach is impacted. The fourth or true stomach is always hyperæmic. As a rule, hæmorrhagic erosions are found in the pyloric portion, still more frequently flat or deep excavations are observed along the mucous folds, with hæmorrhagic base and covered with a slightly elevated greenish-brown slough more or less easily removable. The hæmorrhagic and œdematous changes along the digestive tract and its mesenteries seem to be much more pronounced than in Texas fever, but, as stated above, *Pentastomum* may have something to do with these.

The kidneys are surrounded by hæmorrhagic, œdematous tissue. Frequently the site of a kidney is indicated by a large blackish, hæmorrhagic area. The kidneys are enlarged, the cortical portion dark red. In the pelvis more or less extravasation of blood. The bladder contains much dark-red urine.

The musculature of the body is in parts pale and friable. The membranes of the brain and spinal cord are injected, the nervous tissue rich in blood, sometimes softened and œdematous.

That portion of the work most interesting to us is the description of bodies within the red corpuscles, which are strikingly like the parasite of Texas fever in its intermediate stages. Babes finds peculiar micro-organisms, which he calls bacteria within the red corpuscles in the capillaries of the mucosa of the stomach and intestines, in the mesenteric glands, in the liver, spleen, and kidneys. In the mesenteric glands they were found free in masses. In the kidneys they were exceedingly abundant, both free and within red corpuscles. He also detected them in the musculature of the body, sometimes in the marrow of the bones. In the brain and spinal cord they were not found.

Babes describes these peculiar micro-organisms when stained in Löffler's methylene blue or methyl violet as squarish bodies, each divided by a light line so as to form a body like a diplococcus. The description is vague, but an examination of the illustrations shows that the corpuscles may contain two such diplococci hanging together at one corner and making an angle with each other. Babes finds also that these organisms can not be stained in sections by the current bacteriological methods. He resorts to the following procedure to avoid the decolorizing action of the alcohol: The sections are stained in Löffler's methylene blue for one hour, then dehydrated in an alcoholic solution of methylene blue. Thence they are transferred to an alcoholic solution of eosin and lastly to aniline oil and xylol.

The author believes that owing to the massing together of the "diplococci" in the mesenteric glands, the capillaries of the mucosa of the stomach and the œdemas surrounding these organs that they enter by way of the ulcers of the fourth stomach, become disseminated in the blood, and then attack the red corpuscles. The probable truth of the matter is, however, that the bodies which he saw have already been in corpuscles and have been set free by their breaking down.

Bacteriological observations were made on a certain number of cases, of which some are reported. The whole work is regarded as preliminary, however, for the results are by no means conclusive. Several kinds of bacteria were isolated from oxen which had succumbed to the disease. One of these was cultivated with great difficulty and is fatal to rabbits in about two weeks. Its relation to the disease, though assumed by the author, is not yet proven, since no inoculations are reported which show that it is capable of reproducing the disease in cattle.

In a more recent communication* Babes gives some additional facts bearing on the microörganism of this disease.

The parasites are quite polymorphous. The characteristic form is that of a diplococcus in the interior of the red corpuscle. In other cases there are two or even three pairs of the microörganism in a red corpuscle. The size of these bodies varies. Some individuals are 2 μ, others 0.5 μ in diameter. In the fresh condition they are recognizable within the red corpuscles by their moderate refrangibility and

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*Verhandlungen des X. internationalen medizinischen Congresses (1890). II. Dritte Abtheilung., S. 104–108.

their colorlessness. They do not move within the corpuscles. . Stained with methyl violet their interior shows a peculiar line of division. The microbes are more tubular (*tubisch*), with ends rounded off, and they often hang together by means of a fine thread. Stained blue, the bodies are spherical and the chromatic substance is found more on the periphery. The parasites are colored brown in chromate of potash.

It will be observed that this description accords much more closely than the one given in his first communication with that given in this report of the Texas-fever microörganism. Babes has detected no movement or changes of form of the microörganism within the corpuscles. This may be due to the failure to examine the blood during the life of the animal. In fact, his description of these bodies indicates that he has thus far seen them only post-mortem. He also adds the following information concerning the transmissibility of the disease from one animal to another.

Blood of sick or dead cattle 2 or 3 days old may still produce the disease, but frequently a considerable quantity of fresh blood does not infect them. Undoubtedly this depends upon other conditions of development of the parasite in the animal body. Thus the parasite can only be transmitted once from cow to cow and inoculations from rabbit to rabbit can only be carried through two to three generations with success. Of twelve inoculated beeves only four contracted the disease.

In our experiments the infectious agent has been transmitted from a Southern cow (No. 214) to a Northern cow (No. 222) and from this subsequently to four other Northern cows (Nos. 197, 200, 227, 228) without any diminution of virulence. In fact, three of the four died. As the evidence for the above statement of Babes that the transmission of the disease can be effected but once from cow to cow is not presented we can not examine into it more closely.

As to the cultivation of the microörganism, Babes is more cautious in his statements in this second communication. Of 200 inoculated tubes only twelve showed a feeble growth of diplococci of various sizes. These are said to produce the characteristic disease in rabbits with a hemorrhagic œdematous exudate of the peritoneum and great masses of parasites in the same, exceptionally in blood corpuscles. This sounds more like the more chronic forms of the ordinary *septicœmia hemorrhagica* in rabbit. As to the nature of the microörganism Babes now hesitates to express an opinion, and inclines to the view that it may stand between the bacteria and the protozoa.

It is difficult not to come to the conclusion that this disease is identical with Texas fever. The pathological changes are almost precisely the same, and any minor differences are explainable by the assumption that Babes may have largely examined animals after the acute attack had passed away. The microörganisms of both diseases, their general appearance, their habitat are strikingly alike. The fact that Babes cultivated his organism and produced disease in rabbits is not a strong argument against their identity, for it seems very probable that he may have had under observation one of those not very uncommon bacteria accidentally associated with various disease processes whose form is

too small to resemble anything in particular and the cultivation of which is attended with many failures. Such forms are familiar to most working bacteriologists. It is nevertheless impossible to come to any positive conclusion that the Roumanian and the American diseases are the same until the investigations concerning the former are carried beyond the preliminary stage in which Babes has left them.

In the Caucasus* there prevails a disease during the hot season which is called "Tschichir," a name also applied to a kind of red wine, because the urine of affected cattle is red in color. The disease is said to kill thousands of the best cows and oxen annually, and peasants lose the major part of their stock in a few days without being able to do anything to check the disease. The details concerning the disease are very meager. "At first the animal is dull, with drooping head and ears. It champs its teeth, moans, and discharges from its mouth a viscid, foul-smelling mucus. The bowels may be loose or costive and the urine is bright red." From observations of the disease the following conclusions are drawn:

The "Tschichir" has no infectious properties. The disease attacks mainly working oxen, more rarely milch cows, and never young animals. It is more severe and acute in spring than in fall. It does not last more than three weeks in any one locality. In the first week it begins to show itself, in the second it is at its height, and in the third it disappears completely. The flesh of animals which have died of this disease is consumed without any ill effects by the nomadic tribes of the Caucasus.

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* T. Praktische Bemerkungen über die im Kaukasus Tschichir (Hæmaturia) genannte Krankheit des Hornviehs. Med. Ztg. Russlands, St. Petersburg, 1853, x, 209.

PRACTICAL OBSERVATIONS AND CONCLUSIONS.

It will undoubtedly be conceded by all impartial readers of the foregoing pages that the economic value of the results derived from these investigations is very promising. As yet they are undeveloped, however, and their true importance can not be estimated. Experiments must be built upon them in various directions. These we have thus far been unable to undertake, owing to the large amount of labor involved in determining the relation of ticks to the disease. In the following pages, in addition to deductions immediately available in the control of this disease, a few suggestions are made in regard to the objects to be attained by further investigations and the manner in which they should be conducted. Those readers technically interested in carrying on such investigations will undoubtedly have read between the lines of the foregoing chapters all that can be suggested here.

DIAGNOSIS.

One of the immediate results of the work is the simplicity and ease with which an outbreak of Texas fever can be positively determined. Most veterinarians and pathologists are able to recognize Texas fever when an acute case presents itself for post-mortem examination. The greatly enlarged spleen, the peculiar coloration of the liver, the thick bile, and especially the hæmoglobinuria are so obvious that no one trained to a knowledge of the appearance of the healthy organs and excretions in cattle can make a mistake. But all cases are not in the acute stage at the time of death, and one or several of these important pathological changes may be missing or barely recognizable when present. In fact, there may be no animals which can be sacrificed, and all may be on the road to recovery. In such cases even the clinical signs, such as the high temperature, may be missing.

Among the diagnostic characters to be added to the list are the examination of the blood and the presence or absence of the cattle tick (*Boöphilus bovis*). We may now consider it demonstrated that Texas fever outbreaks in the North are not possible without the cattle tick. Isolated cases may occur through other agencies perhaps, but no general infection of fields or pastures is possible without the cattle tick. Hence, in any doubtful disease where Texas fever is suspected, ticks should be looked for, and in doing so all those facts concerning the size of the ticks on animals in the acute stage and during recovery and their location on the body must be borne in mind. On animals which have

passed through the disease the ticks are nearly or quite full grown and therefore easily detected. But even when great care is exercised the ticks may be overlooked or in a late fall infection they may have speedily disappeared. In such cases the examination of the blood will give the necessary information. This requires some skill, and a good microscope with objectives and oculars giving a magnification of not less than 500 diameters is necessary. The method of examination as well as the pitfalls to be avoided in interpreting appearances under the microscope have been discussed at length, and need not be again referred to here.* While the presence of the micro-parasite within the red blood corpuscles and the changed size and appearance of many of the corpuscles themselves are usually of sufficient diagnostic value, it is always desirable that the number of red corpuscles be estimated at the same time.

In the microscopic examination of the blood attention should be paid, first of all, to the presence of the various stages of the micro-parasite. In the mild type, the minute coccus-like body will be found within the corpuscle, near its periphery. As it is rarely seen in fresh preparations, stained preparations should invariably be examined. In the acute type of midsummer, associated with high fever, the larger, paired, pyriform bodies are always present, but usually in very small numbers. They may be detected as readily in fresh blood carefully mounted as in dried and stained preparations. Next in importance to the micro-parasite of the disease are the changes induced in the blood corpuscles by the anæmia. In fresh blood the variation in size of the individual corpuscles and the very large size of many (from one and one-half to one and three-quarters times the diameter of the normal red corpuscles) is at once apparent. In properly stained preparations the peculiar granulations and the diffusely stained appearance of a greater or smaller number of the large corpuscles as depicted on Plate IX and other plates is quite characteristic. These changes may, of course, be the result of very severe, repeated hemorrhages, and these must be excluded first before the former can be considered as due to Texas fever. The changes in the blood corpuscles may be directly associated with the parasite in the mild type, but they usually follow the parasite in the acute type. Hence they may be the only indication of disease recognizable under the microscope in some cases.

A reduction in the number of corpuscles is a very reliable sign of Texas fever. If we except the occurrence of severe hemorrhages and the feeding of chemical poisons, their number is but slightly, if at all, influenced by diseases of various kinds. In several cases of advanced tuberculosis no reduction was noticed. In fact there seems to be but little specific action of bacterial poisons on the red corpuscles, while the Texas fever microbe limits its destructive action entirely to them. Anæmia in cattle seems to be rare, as we found it but once among the

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* Page 42.

many cases under observation. Hence the counting apparatus is of great service in detecting Texas fever in all its phases and should be used whenever possible.

A summary of the diagnostic characters to be looked for when this disease is suspected would include among others the following salient ones:

(1) Cattle ticks.

(2) Gross pathological changes: Hæmoglobinuria; enlarged spleen; enlarged, yellowish liver; thick, flaky bile; ecchymoses on the external and internal surfaces of the heart.

(3) The micro-parasite within the red corpuscles.

(4) Modified or changed corpuscles (enlargement, the presence of stainable granules, etc.).

(5) The reduction in the number of red corpuscles.

PREVENTION.

Texas fever in the territory outside of the enzoötic region is the result of the distribution of ripe egg-laying ticks by cattle from the enzoötic region. Hence such cattle should not be allowed on uninfected territory during the warmer half of the year. It is also evident that all cars carrying Southern cattle contain a larger or smaller number of ticks which have dropped off during the journey and which are ready to lay their eggs. The sweepings of such cars, wherever deposited, may give rise to a crop of young ticks and these, when they have access to cattle, will produce the disease. Wherever Southern tick-bearing cattle are kept within twenty-five to thirty days after their departure from their native fields they are liable to infect such places, since it requires the period mentioned for the smaller ticks to ripen and drop off. But under special conditions even this period is too short and the Southern cattle may remain dangerous a longer time. This would occur when such cattle remain in any one inclosure long enough (four to five weeks) for the progeny of the first ticks which drop off to appear on the same cattle.

The above points are covered in the regulations of the Department of Agriculture concerning cattle transportation. These regulations insist on the complete isolation of cattle coming from the permanently infected territory between March 1 and December 1 of each year and on the proper disinfection of the litter and manure from such cattle during transportation. Furthermore such cattle can only be transported into uninfected territory for immediate slaughter during the prescribed period. These regulations if properly carried out would prevent the appearance of Texas fever at any time in those areas north of the enzoötic territory. The only question which now presents itself with reference to them is the efficiency of the prescribed disinfection. It has been shown that the infection resides only in the cattle ticks and their eggs; hence the destruction of these is absolutely essential

to make the disinfection of any value. In the present report this question has not been touched upon; therefore, pending the trial of various disinfectants, which is now going on, any discussion or any suggestions are of little value.

The harmlessness of Southern cattle after being deprived of the cattle tick brings up the very important question whether such cattle can not by some means be freed from ticks so that their transportation may go on without any restriction during the entire year. There are several ways in which experiments might be undertaken. Cattle might be subjected to disinfecting washes of various kinds, or else they might be run through disinfecting baths which expose the whole body to the action of the liquid used. Such processes would require careful attention. The survival of a very few ticks might lead to serious consequences, since a single ripe tick averages about 2,000 eggs.

Cattle may be deprived of ticks on a large scale without the use of any disinfection if the following plan be adopted: Two large fields in a territory naturally free from cattle ticks are inclosed. The tick-bearing cattle are put into the first inclosure and kept there about fifteen days. They are then transferred to the second inclosure for the same length of time. Thirty days after the beginning of their confinement they may be considered free from infection. The reason for this procedure is simple enough. The cattle drop the ticks as they ripen in the inclosures. By being transferred to a second (or even a third) inclosure they are removed from the possible danger of a reinfection by the progeny of the ticks which dropped off first. It is evident that such inclosures can only be used once a season, since the young ticks subsequently hatched remain alive for an indefinite length of time on the ground. Such inclosures must not be located where there is a possibility that the ticks might survive the winter.

For cattle which are introduced into the enzoötic territory two modes of prevention may be adopted. Either they are kept entirely free from ticks by confinement in stables or upon pastures known to be free from ticks, or else they are exposed to the infection in such a way as to become insusceptible to it after a time. The first method is open to the objection that ticks may at some time accidentally gain access to such cattle and produce a fatal disease. The second method seems the more rational, provided it can be successfully carried out. We know that Southern cattle are insusceptible to the disease, and the way in which this insusceptibility has been acquired has been already discussed (p. 130). Young animals seem to be largely proof against a fatal infection, although they are by no means insusceptible. The repeated mild attacks to which they are subjected finally makes the system indifferent to the virus. The introduction of young animals into the permanently infected territory, though not without danger, is far safer than the introduction of animals older than one year. The danger of a fatal infection increases with the age of the animal and is very great in cows over 5 or

6 years old, as is distinctly shown by the experiments recorded in this report.

The subject of preventive inoculation has already been discussed and experiments cited on page 132. It has been shown that while in general two mild attacks may not prevent a third attack, this will not be fatal. One very acute attack will usually prevent a second severe attack. Hence it is possible to prevent cattle, even when fairly along in years, from succumbing to a fatal attack by several preliminary carefully guarded exposures to a mild infection. This infection may be produced by scattering ripe ticks in an enclosure, or by placing young ticks on cattle in the fall of the year (page 135). Protective inoculation of this kind should be carried on at some locality outside of the enzoötic territory carefully chosen for the purpose. A few years of careful experimentation would probably lead to an efficient method which, when definitely formulated in all its details, could be applied in different parts of the country. Such experimentation should, of course, pay special attention to the relative susceptibility of the various higher grades of cattle, a matter which we have been unable to touch upon thus far.

What can the individual farmer or stock-owner do in the event that Texas fever has been introduced into his pastures? From what has been said thus far pastures which have been infected by Southern cattle or ticks from the litter and manure of infected cattle cars should be avoided during the entire summer season. While we know that young ticks may remain alive in jars for two or three months without food, it would be premature to conclude that such is the case on pastures, as the conditions are quite different. Yet everything seems to point to a long sojourn of young ticks on infected fields, and pending the carrying out of experiments to test this question we would recommend that native cattle be not allowed to graze on infected fields until after the first frosts, for even a mild attack in fall before the ticks have been destroyed by frosts is debilitating to cattle. The period of time during which infected localities remain dangerous varies, of course, with the latitude, and would be shorter the colder the climate.

The infection of stables, stalls, and other structures with the ticks should be counteracted by thorough disinfection. The adult ticks and the eggs must be destroyed. As stated above, we know as yet very little concerning the agents which will destroy the vitality of the eggs of ticks, but the use of water near the boiling point may be sufficient, if liberally applied, to destroy the life of the embryos. In the case of litter and manure heaps the thorough saturation with some strong mineral acid in dilution may accomplish the purpose. Ordinary lime, slaked or unslaked, densely sprinkled over infected places so as to form a continuous layer may be recommended. The slow incrustation of the egg masses with carbonate of lime may be expected, provided the manure is under cover. Otherwise it will be washed away and may

leave the eggs unharmed. In regions outside of the enzoötic territory the absence of ticks may be accounted for by the severity of the winter; hence in unprotected localities disinfection is unnecessary after the winter has set in. But it may occur that in sheltered places the eggs will winter over and the ticks reappear the following spring. Whether such ticks are likely to produce any serious trouble in the absence of Southern cattle we are unable to state definitely. All that we know is that disease may break out when Southern cattle of the preceding year are in the pasture, as was demonstrated accidentally in our investigations during 1891. (See p. 120 and No. 154.) Hence all infected material should be freely exposed to the frost, even though treated with disinfectants beforehand.

TREATMENT.

If the disease is suspected in a herd, the animals should be searched thoroughly for the presence of small ticks and the temperature of every animal taken with a clinical thermometer with which every stock-owner should be provided. This, which should be 5 inches long, is inserted well into the rectum and held there 3 to 5 minutes. If the temperature is 104° to 107° F., fever is present. The combination of ticks and fever, or the presence of the former in a locality where they do not naturally exist, may be considered a sure sign of the imminence of Texas fever. Though there are at least two species of ticks regularly infesting cattle in the permanently infected territory, these remarks can apply only to the species described in this report, since we know nothing as yet of the fever-producing capacity of the other species (*Amblyomma unipunctata*).

In case the ticks are found on the cattle they should be carefully removed and the cattle transferred at once to uninfected grounds. The cattle should be repeatedly examined for ticks and all found destroyed. While the change of pasture and the removal of ticks may not prevent the attack nor cut short the disease after it has once shown itself, we feel certain that fewer animals will succumb to it. A single infection is sufficient to cause severe and prolonged disease, as is shown by the injection of infected blood; but the mortality seems to be lower than in natural exposures, where the infection is intensified with every additional tick.

We are unable to recommend any specific remedies to be applied after the disease has appeared, because none have been tried as yet. Quinine and its various preparations fed or injected under the skin may prove of value in destroying the parasite, or perhaps methylene blue, recently recommended for malaria, may be of some service. We hesitate, however, to do more than suggest these remedies, since their efficiency should first be carefully tested by well-planned experiments, which should only be undertaken on a large scale with a sufficient number of control animals and guided by a repeated examination of the blood.

The general indications to be followed in attempting to save diseased animals are perfect rest in a sheltered place. Sick animals should not be driven or excited, for the condition of the circulation is such that any effort may bring about rupture of blood vessels and lead to speedy death. The heart, moreover, is always seriously involved and should not be strained in any way. Again, the exposure of sick cattle in the sun's heat without shelter is liable to increase the already abnormally high temperature. We have, in fact, observed on unsheltered fields during very hot days a rise of from 2 to 3 degrees F. in presumably healthy cattle during the day, which we must attribute to the effect of the sun's heat. A sheltered place, preferably in the open air, in which the sick animal remains free from the annoyances of other animals, is therefore best suited to its condition. An abundance of pure water should be supplied to aid the overtaxed liver and kidneys to excrete their abnormal products in a more diluted condition. The food given should be readily digestible. It may be on the whole better to withhold food entirely until the high temperature begins to subside, since the various digestive organs are in a congested state and not in a condition to do any work.

The disinfection of infected pastures is out of the question, and must be left to nature in winter. They may, however, be used for sheep, since we have found these animals unharmed after grazing on them during an entire summer. It is highly probable that all other domesticated animals may run over such pastures with impunity, since Texas fever outside of the bovine species has not yet been observed.

CONCLUSIONS.

(1) Texas cattle fever is a disease of the blood, characterized by a destruction of red corpuscles. The symptoms are partly due to the anæmia produced; partly to the large amount of débris in the blood, which is excreted with difficulty, and which causes derangement of the organs occupied with its removal.

(2) The destruction of the red corpuscles is due to a microörganism or micro-parasite which lives within them. It belongs to the protozoa and passes through several distinct phases in the blood.

(3) Cattle from the permanently infected territory, though otherwise healthy, carry the micro-parasite of Texas fever in their blood.

(4) Texas fever may be produced in susceptible cattle by the direct inoculation of blood containing the micro-parasite.

(5) Texas fever in nature is transmitted from cattle which come from the permanently infected territory to cattle outside of this territory by the cattle tick (*Boöphilus bovis*).

(6) The infection is carried by the progeny of the ticks which matured on infected cattle, and is inoculated by them directly into the blood of susceptible cattle.

(7) Sick natives may be a source of infection (when ticks are present).

(8) Texas fever is more fatal to adult than to young cattle.

(9) Two mild attacks or one severe attack will probably prevent a subsequent fatal attack in every case.

(10) Sheep, rabbits, guinea-pigs, and pigeons are insusceptible to direct inoculation. (Other animals have not been tested.)

(11) In the diagnosis of Texas fever in the living animal the blood should always be examined microscopically if possible.

DESCRIPTION OF PLATES.

Every figure illustrative of red blood corpuscles containing the parasites or modified by the disease, was made from one field of the microscope, and this only, unless especially mentioned to the contrary in the descriptions below. The drawings are therefore equivalent to photographic reproductions, in so far as nothing was omitted from the field or inserted from other fields (with exceptions to be given). The slight differences in the coloring is due to the different intensity of the stain in the preparations, and was copied as accurately as possible by the artist.

The preparations illustrating blood corpuscles were all drawn with the aid of a Zeiss apochromatic objective, 2mm, 1.30 n. a. and the measurements made with the compensating micrometer ocular No. 6. The occasional variation in the magnification is due to the fact that the earlier drawings were made with the draw tube in, the later ones with the tube length so adjusted that each division of the ocular micrometer was exactly equivalent to 2 μ. The history of the cases from which the drawings were made may be found recorded in detail in the appendix.

PLATE I. Diseased and healthy spleen.

Fig. 1. Spleen of No. 130. The smaller ventral end is here represented. Weight of entire spleen 6¾ pounds

Fig. 2. Spleen of healthy steer killed for beef. The same region selected as in the diseased spleen. Weight 2⅝ pounds.

Note the enormous enlargement of the diseased spleen, the almost blackish appearance of the pulp, and the concealment of the trabeculæ and Malpighian bodies as compared with the healthy spleen. The ratio of the weight of the diseased to that of the healthy spleen is in this case as 2½ to 1, while the weights of the animals is as 2 to 3 (800 to 1,200).

PLATE II. Diseased and healthy liver.

Fig. 1. Liver of No. 50. The figure shows the cut surface at right angles to the peritoneal surface.

Fig. 2. Cut surface of the same liver enlarged two diameters to show the distribution of the yellowish zones along the course of the hepatic vessels.

Fig. 3. Cut surface of healthy liver. The coloring is not properly reproduced in this figure.

Fig. 4. Section parallel to the peritoneal surface of fresh liver from No. 106, in iodized serum. Slightly magnified. The yellow regions correspond to the regions in which the bile capillaries are distended with bile.

PLATE III. Bile stasis and hæmoglobinuria.

Fig. 1. Section from liver of No. 130. Cut on freezing microtome, stained in alum carmine, floated upon the slide, dried in thermostat and mounted in xylol balsam. Drawn with Zeiss apochr. 4 mm. and compens. ocular 4. Outlined with camera lucida. (× 250.) The hepatic cells are shown to be inclosed in a network of bile canaliculi distended with rods of solid bile. The space to the left represents the intralobular vein.

PLATE III—Continued.

Fig. 2. From a fresh section of liver of No. 144, showing the network of injected bile canaliculi and the needle-like, red crystals.

Fig. 3. Rods of solid bile obtained from teased preparations of the liver of No. 184. (× 1,000.)

Fig. 4. Urine from No. 80.

PLATE IV. Microörganism of Texas fever.

Fig. 1. Blood from a skin incision of No. 74, taken September 30, 1890. The blood was spread in a thin layer on a cover-glass as described in the text, dried in the air. Subsequently heated for one to two hours in a dry hot-air oven at 110°–120° C. Stained for two to three minutes in Löffler's alkaline methylene blue, washed in water, then dipped for a moment in a one-third per cent solution of acetic acid, washed again, dried in the air, and finally mounted in xylol balsam. The micro-parasite is represented by the exceedingly minute blue points within the red corpuscles.

In this preparation the infection is shown to be very extensive. This is the only case in which the parasite was detected in this exceedingly minute stage. (× 1,000.)

Fig. 2. Cover-glass preparation of spleen pulp from No. 70. Stained as described in Fig. 1 above. The intraglobular bodies are slightly larger than those of Fig. 1. (× 900.)

Fig. 3. Blood from a skin incision of No. 160. Prepared November 7, 1891. Method as described. The small bodies are situated within the red corpuscles near the periphery. The large red corpuscle in the center containing a number of stained particles of different sizes is a result of the loss of corpuscles, or anæmia. (× 1,000.)

Fig. 4. Cover-glass preparation from kidney of No. 130. Method of fixing and staining as described above. The large, blue body in the center of the group is one of the cellular elements of the kidney. The parasites are usually in pairs, and roundish. This form is generally assumed in the dead body. (× 1,000.)

Fig. 5. Preparation made by rubbing a piece of the heart muscle of No. 186 on a cover-glass, drying and staining as before. In this way the blood corpuscles from the smaller vessels and capillaries are obtained. The large blue body represents a leucocyte. The parasites are mostly in pairs and pear-shaped. (× 1,000.)

PLATE V.

Fig. 1. Cover-glass preparation of spleen pulp from No. 66. The two large blue bodies represent cell elements of the spleen pulp, and the uniformly bluish-pink body represents an "anæmic" red corpuscle. The red corpuscles are mostly larger than normal, owing to the anæmic condition induced in the animal before death. Many parasites are in pairs and have assumed the spherical form. The animal had died in the night. (× 1,000.)

Fig. 2. Preparation made as before from blood taken from a skin incision of No. 106, August 27, 1890, less than twenty hours before death. The appearance of the infected corpuscles in groups, as shown in the figure, was especially marked in this animal. The parasites are mainly in pairs, and pyriform. The stained body on the right is a white corpuscle. The large parasite in a corpuscle to the left was drawn in from an adjacent field. The reddish color of the stained bodies is due to the fact that the preparation was drawn while still mounted in water, which partly dissolved out the coloring matter. (× 1,000.)

Fig. 3. Cover-glass preparation of blood taken from a skin incision of No. 185, October 9, 1891. (Case of intravenous injection of Texas-fever blood.) On this date only about 1,000,000 red corpuscles in a cmm. All objects within the dotted line are in one field of the microscope. The rest are drawn in

PLATE V—Continued.

from other fields in the same preparation. *a* represents modified red corpuscles, *b* a leucocyte, *c* a hæmatoblast, and *d* the parasites. Note the variation in the size of the red corpuscles. The parasites are mainly in pairs. They vary in size and form, and perhaps represent stages of degeneration. (× 1,000.)

PLATE VI. Microörganism of Texas fever.

Fig. 1. Vascular fringes on omentum of No. 130, crushed on cover-glass. Dried and stained as before (×1,000). Shows the extensive infection of blood corpuscles in the capillaries. The large blue body represents a cellular element. One corpuscle shows a double infection. The parasites are mainly pyriform.

Fig. 2. Heart muscle of No. 130, crushed on cover-glass, dried and stained to show presence of parasites freed by the disintegration of the infected corpuscles. One corpuscle in the lower part of the figure to the right shows faintly. The two pairs of free parasites above are drawn in from another field.

Fig. 3. Preparation from kidney of No. 74, showing the large number of freed parasites in addition to an extensive infection of the red corpuscles. The free bodies largely in pairs.

Fig. 4. Infected corpuscle, unstained, from cutaneous blood of No. 56, collected November 28, 1890. Each pyriform body is provided with a minute dark body not seen in stained preparations. (× 1,000.)

Fig. 5. A similar pair of parasites, unstained, from No. 130. Taken December 30, 1890. (× 1,000.)

Fig. 6. A spherical form from the same case at the same time.

Fig. 7. Stained corpuscle from cutaneous blood of No. 137, prepared November 6, 1890, shortly before it was killed, showing how large these bodies may occasionally become with reference to the enveloping corpuscle. Note also the peripheral stain.

Fig. 8. Free parasites not infrequently observed in crushed, fresh, and unstained preparations from heart muscle of various cases. They are seen usually in pairs.

Fig. 9. A series of corpuscles containing bright motile bodies, observed both in health and disease. Somewhat coarsely outlined.

Fig. 10. Path of one of the bright motile bodies within a red corpuscle, as observed during a period of 15 minutes. Sketched from a fresh preparation of cutaneous blood from No. 107, August 25, 1890.

PLATE VII.

Fig. 1. Capillary from heart muscle of No. 181. From tissue hardened in Müller's fluid and alcohol. Sections cut after imbedding in paraffin and fastened to the slide with a few drops of 70 per cent alcohol. Stained for an hour in Ehrlich's acid hematoxylin and eosin, dehydrated in alcohol containing eosin, cleared in clove oil, and mounted in xylol balsam. There are a considerable number of parasites in pairs within the red corpuscles, the majority of which show only in outline, since they have lost their coloring matter, probably as a result of disintegration. (× 500.)

Fig. 2. Capillary from the medullary portion of kidney of No. 186. Nearly every corpuscle contains a pair of parasites. Those drawn in shadow below the optical section in focus are also infected. The section was prepared in the same manner as detailed above, with the exception that it was not fastened to the cover glass and not passed through eosin alcohol. (× 500.)

Fig. 3. Capillary containing infected corpuscles almost exclusively. From a teased preparation of fresh spleen pulp of No. 134, in iodized serum. The unstained parasites appear as minute round white spots in the corpuscles. (× 500.)

PLATE VIII. Amœboid changes of the microörganism of Texas fever.

Fig. 1. Fresh preparation of blood from No. 69, five hours post-mortem. Preparation sealed with paraffin and kept in a warm chamber with microscope at 35°–40° C. Showing changes of form in an intraglobular parasite.

Nos. 1 to 6, changes going on as fast as could be sketched.

Nos. 7 to 15, sketched twenty minutes later.

Fig. 2. An intraglobular parasite in subcutaneous blood of No. 95 a few hours before death, showing changes of outline.

Fig. 3. Another parasite from the same source, showing similar changes.

Fig. 4. Parasites showing a nuclear (?) body from the same source.

Fig. 5. Similar parasites sketched from the fresh cutaneous blood of No. 90, shortly before death. Note the different forms and relative positions occupied by the intraglobular parasites as well as the presence of the nuclear (?) body.

PLATE IX. Modified or embryonic red corpuscles after severe hemorrhage and after Texas fever.

Fig. 1. Blood from sheep No. 160, upon which venesection had been practiced. Prepared July 7, 1890, after the number of red corpuscles had been reduced from 11 to 5½ millions. Dried and stained as described for Fig. 1 on Plate IV. Note variation in the size of the normal corpuscles and the presence of large corpuscles containing a large number of stained particles or granules of variable size. (× 1,000.)

Fig. 2. Another field from the same preparation, showing also a tinted form without granules. (× 1,000.)

Fig. 3. Cutaneous blood from cow No. 168, drawn August 12, 1891, after the red corpuscles had been reduced by venesection from 6½ to 2 millions. Stained as indicated in Fig. 1. Note the presence of large and small granules in the corpuscles; also a uniformly stained corpuscle. (× 1,000.)

Fig. 4. From another field of the same preparation, showing two large corpuscles containing stained granules. (× 1,000.)

Fig. 5. Cutaneous blood from No. 160 (case of Texas fever). Preparation made November 12, 1891. A corpuscle on the left contains a Texas-fever parasite. (× 1,000.)

Fig. 6. Another field of the same preparation, showing uniformly stained as well as granular red corpuscles. Note also the great variation in size of the corpuscles having a normal appearance. (× 1,000.)

PLATE X. The cattle tick—the carrier of Texas fever.

(Figs. 1, 3, 4, and 5 were drawn under the direction of Dr. Curtice. Nos. 4 and 5 were slightly modified before insertion.)

Fig. 1. A series of ticks from the smallest, just hatched from the egg to the matured female ready to lay eggs.

Fig. 2. Eggs magnified 5 diameters.

Fig. 3. The young tick just hatched (× 40).

Fig. 4. The sexually mature male after the last moult. Dorsal view. (× 10.)

Fig. 5. The sexually mature female after the last moult. Dorsal view. (× 10.)

Fig. 6. A portion of the skin of the udder of No. 140. (Ticks artificially hatched and put on when small.)

Fig. 7. A portion of the ear of the same animal, showing adults ready to drop off and lay their eggs.

PLATE I

Fig. 2

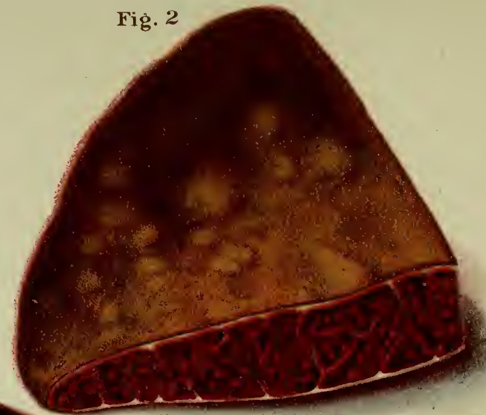

Fig. 1

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DISEASED AND HEALTHY SPLEEN.

PLATE II

Fig. 1

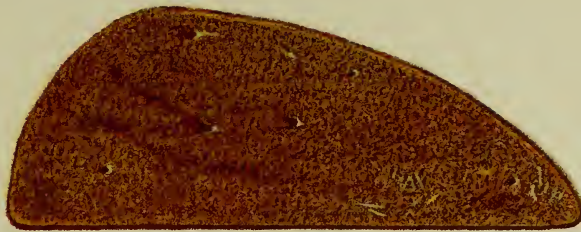

Fig. 2

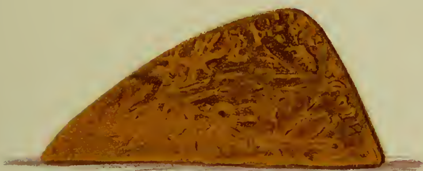

Fig. 3

Fig. 4

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Haines, del.

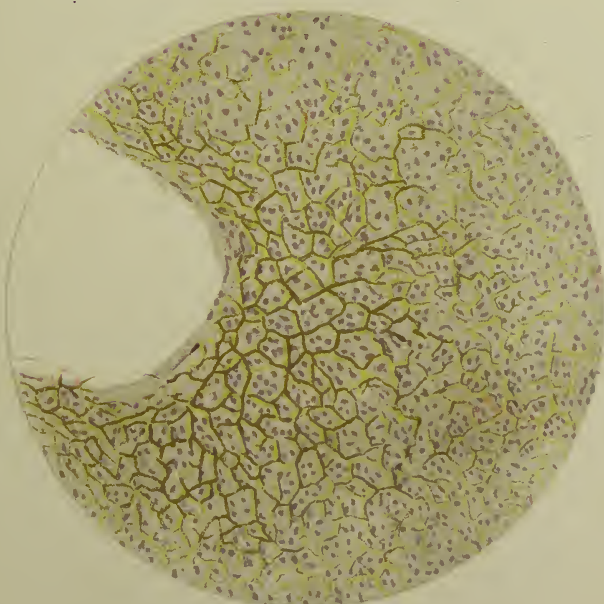
DISEASED AND HEALTHY LIVER.

Fig. 4

Fig. 2

Fig. 3

Fig. 1



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BILE STASIS AND HÆMOGLOBINURIA.

PLATE IV

Fig. 1

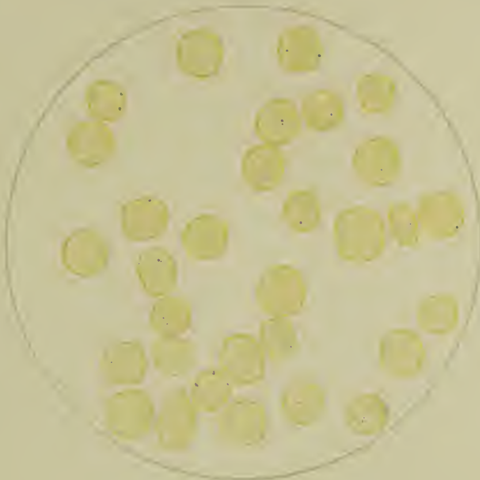


Fig. 2

Fig. 3

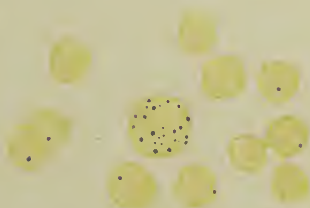
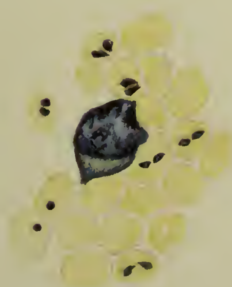


Fig. 4

Fig. 5



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MICRO-ORGANISM WITHIN THE RED BLOOD CORPUSCLES.

PLATE V

Fig. 1

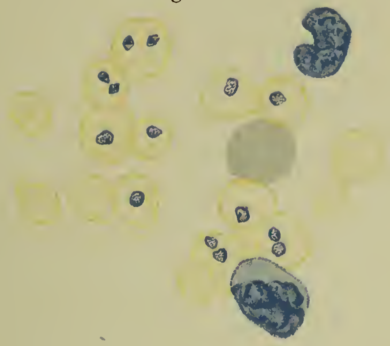


Fig. 2

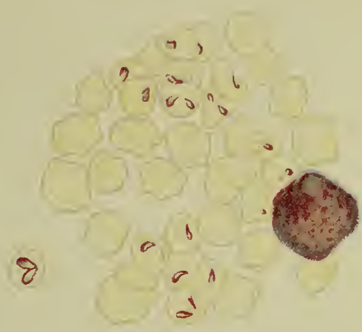
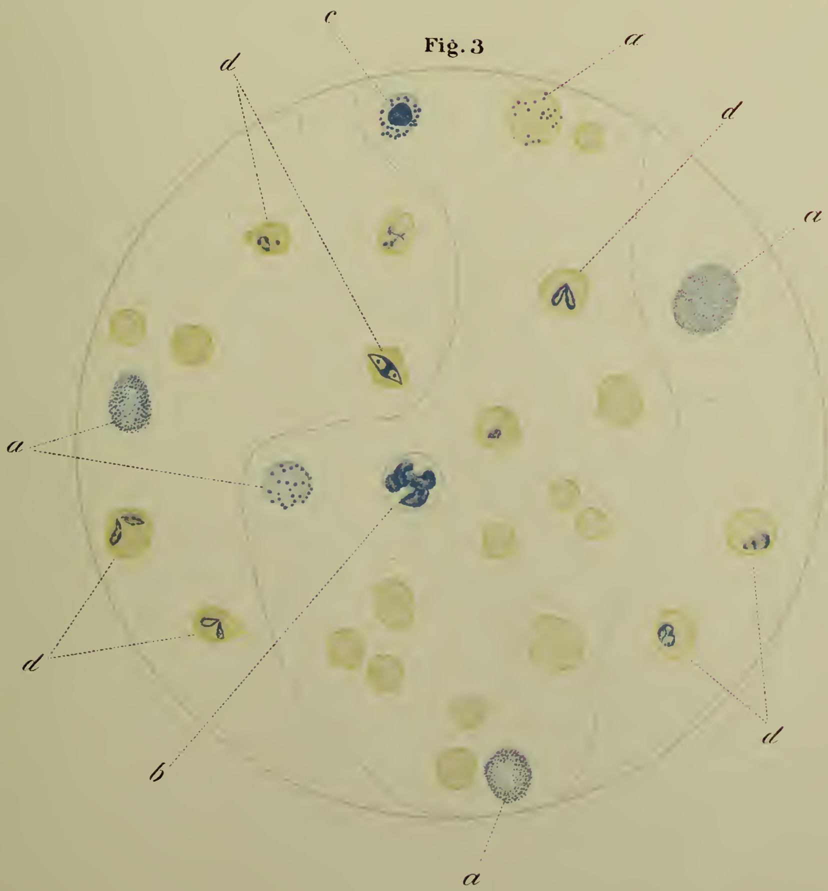


Fig. 3



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MICRO-ORGANISM WITHIN THE RED BLOOD CORPUSCLES.

Fig. 1

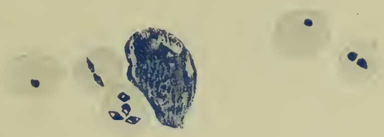

Fig. 2

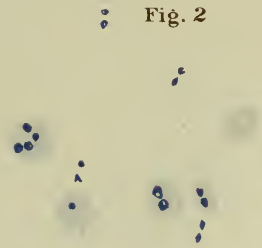

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7

Fig. 8

Fig. 10

Fig. 9

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MICRO-ORGANISM OF TEXAS FEVER.

PLATE VII

Fig. 1

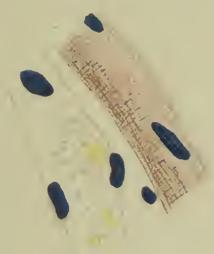

Fig. 2

Fig. 3

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CAPILLARIES FILLED WITH INFECTED CORPUSCLES.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

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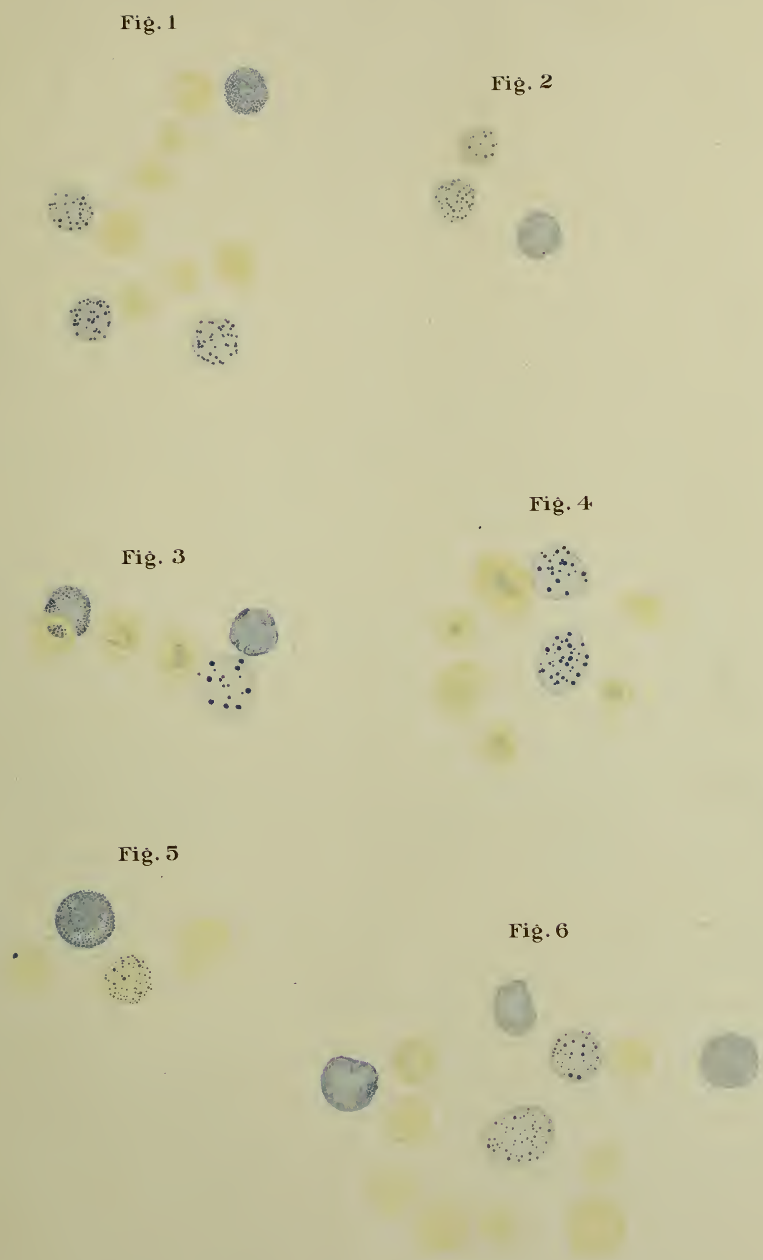
PARASITE IN THE BLOOD CORPUSCLES.

Figs. 1, 2 and 3 show amœboid changes.



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MODIFIED (Embryonic) RED BLOOD CORPUSCLES AFTER SEVERE HEMORRHAGE AND AFTER TEXAS FEVER.

Fig. 1

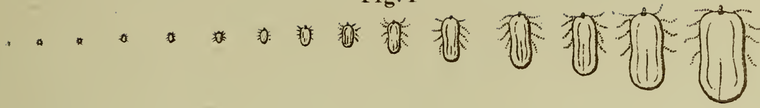


Fig. 2

Fig. 3

Fig. 4

Fig. 5

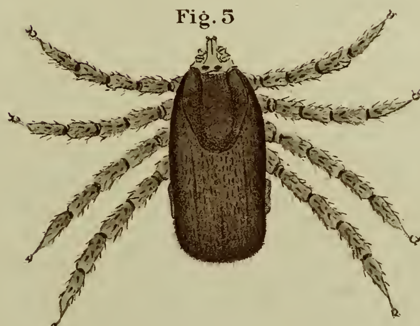
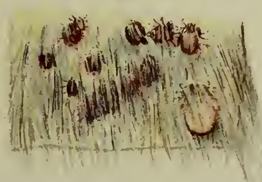


Fig. 7

Fig. 6



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THE CATTLE TICK- THE CARRIER OF TEXAS FEVER.

APPENDIX.

EXPLANATORY INTRODUCTION TO NOTES AND TABLES.

In the following pages will be found the various observations upon the cases of Texas fever investigated upon which the deductions in the foregoing report are based. They consist of clinical, pathological, bacteriological, and microscopical observations, and are given as fully as is possible without going into frequently repeated details. The terms used will not in general be intelligible without the text and the notes as a whole are not intended to replace this. They may in fact be entirely passed over by those not especially interested in the methods and details of the work.

The cases are arranged with regard to the numbers which the animals accidentally bore and not with regard to the experiments of which they formed a part. This method was adopted to facilitate reference while reading the text in which the general plan of all experiments may be found. Frequent reference is made to special cases by the numbers of the animals, and the appendix may thus be regarded as a kind of index to the text. This plan of transferring the greater part of the experimental detail to a compact appendix is tried with the hope that it will make the text less bulky and hence more readable, while including everything that may be necessary to an impartial judgment on the part of the reader. The arrangement therefore throws cases together which perhaps belong to different experiments in different fields. But the material has grown so bulky that any other arrangement would be more confusing than this seems to be. As the appendix has been entirely subordinated to the text proper the serial arrangement by numbers remained the only altermative. It was thought best to include the temperature records of all animals in their entirety, and these will be found at the end arranged, not numerically, but with reference to the experiment to which each animal belonged. Under each case the page where such record can be found is given.

In order to facilitate the reading of the notes the observations upon many of the cases have been thrown into a tabular form. This necessitated very brief statements concerning the condition of the blood and the parasite, which in some respects is to be regretted. This tabular form is, however, so much superior in permitting a ready comparison of the condition of the blood, etc., from time to time, that it was

nevertheless used in all cases in which the examination of the blood was frequently made.

In the interpretation of the tables the following things should be borne in mind: In quoting the number of red blood corpuscles the three last figures have in general been replaced by ciphers to facilitate and simplify the reading.

The sign of equality indicates the same condition as in the column immediately preceding.

The third and fourth columns always refer, unless it is otherwise stated, to bodies within the red blood corpuscles. A record has been made of the occurrence of the so-called bright bodies described on page 56 because of a possible connection of some of them with the earliest stages of the Texas-fever parasite as suggested on page 68.

The estimated percentage of infection is not from actual counting of the corpuscles in the dried and stained films (as this would have consumed an amount of time not warranted by the results), but is a simple approximation or guess from the examination of a large number of fields. In those cases in which the infection is very slight and indicated by actual figures (as "one bright body," "three pairs pyriform bodies," etc.) these are based on the more or less prolonged examination of a single cover-glass preparation. This does not mean, however, that only one preparation was examined. Not infrequently three or four in doubtful cases were examined at different intervals. The same may be said of those preparations in which no intraglobular bodies were found. In some cases one, in others two or three, were carefully scrutinized. It is of course evident that the absence of all parasites from the blood can not be predicated when the evidence is based on the examination of a very small quantity of blood. It may be said that at least several thousand red corpuscles were passed in review in every preparation.

Attention is likewise called to the fact that the two columns giving the result of the examination of the blood in the fresh and in the dried and stained condition are not necessarily identical, but supplement one another as to the information given. Thus the minute bright, intraglobular bodies are visible only in fresh blood. The reverse is true of the earlier coccus-like forms of the parasite, which are rarely visible in the fresh blood.

The fifth and sixth columns of the tables refer to the condition of the red corpuscles at the time of the examination. The importance of a recognition of their condition in the study and diagnosis of Texas fever has been fully discussed on pages 46 and 146.

The record of the pulse and respiration is not reliable in many cases, owing to the excitability of the animals on being caught. This unreliability disappears more or less during the fever, since they are then easily caught and manifest little if any excitement.

In the notes on the individual cases, facts obtained by subsequent microscopical and bacteriological examination of tissues have been

placed with the gross post-mortem notes to simplify the arrangement. For instance, the result of the examination of hardened tissues, which in a few cases was delayed a year or even longer, is quoted in the post-mortem notes, thereby bringing all the observations upon any one organ together. In some cases discoveries have been anticipated in rewriting the notes. Though the cause of the minute worm pits in the fourth stomach was not recognized until the fall of 1890 (see page 33) the lesions in some earlier cases have been referred to the strongyle in writing up the notes for publication.

In general, the notes of the later cases are fuller with reference to the microörganism, and perhaps more exact, and the reader is referred to them more particularly. It was thought best, however, to include the notes of all the cases which have entered into the field experiments in order to preclude any doubts in the mind of the reader as to the correctness of the inferences drawn from these field experiments. Many of the notes are, therefore, merely of diagnostic value, and their meagerness in other respects is excusable on the ground that it was a physical impossibility during the prevalence of the acute disease in summer to do justice to all cases which came under observation.

For the diagrams of the field inclosures see pp. 94, 99, 102, and 108.

SOME PRELIMINARY BACTERIOLOGICAL OBSERVATIONS.

The following observations were made on material brought to the laboratory in Washington, D. C. Cases No. 1 and 2 belonged to an outbreak near Hamilton, Va., in 1886. Cases No. 3–6, inclusive, belonged to an outbreak in Carroll County, Md., in 1888. Dr. Cooper Curtice reported the field notes of this outbreak in the volume comprising the fourth and fifth annual reports of the Bureau of Animal Industry (p. 429):

Case 1—(August 30, 1886). Spleen from a case of Texas fever which had died during the night at Hamilton, Va. About four times the normal size. Wrapped in cloths saturated with a one-tenth per cent solution of mercuric chloride, brought to the laboratory and kept on ice until next morning. Cultures were made from the spleen pulp which was very soft, dark-colored, by making several successive incisions with sterile knives and withdrawing bits of pulp with loops.

September 1.—Three tubes of neutralized beef infusion peptone, into which small bits of the pulp had been dropped, were faintly clouded to-day. One contained two forms of bacilli, a slender and a plump form; the second, a large bacillus and a micrococcus; the third, a large spore-bearing bacillus and a slender one. Two tubes of the same culture liquid, into which the platinum loop previously forced into the spleen pulp was dipped, remained sterile. Of two tubes of blood serum, inoculated with bits of spleen tissue, one remained free from growth, the other contained a plump bacillus. Several gelatin-plate cultures made at the same time remained free from growth.

A portion of the same spleen was kept in a warm room for one day wrapped in sublimated cloths. The pulp then examined microscopically contained two forms of bacilli, a plump and a slender form, the former in chains, the latter predominating in numbers. Three tubes of gelatin inoculated therefrom were liquefied in a few days and contained the same organism found in the liquid cultures.

The various forms thus brought to light no doubt found their way into the spleen soon after the death of the animal, and the want of uniformity in the results of the cultivations indicated that nothing could be expected from them.

Case 2.—September 1, 1886. Another cow died this morning at Hamilton, Va. The spleen was immediately removed, wrapped in sublimated cloths, and kept on ice until it could be examined next morning.

This organ is likewise very large, the tissue disintegrated and very dark. No bacteria could be seen in cover-glass preparations. In or on many red blood-corpuscles there are small round bodies perhaps 1 μ in diameter, centrally or slightly eccentrically situated, which stain poorly in an aqueous solution of methyl violet, very well in methyl violet to which aniline water has been added (Koch-Ehrlich tubercle stain). They then resemble micrococci in size and form. Only a few are found outside of the corpuscles. Unstained they can be seen as mere transparent spaces in the corpuscles.

Five tubes containing bouillon peptone were inoculated from the spleen, three with the platinum loop simply, two with bits of tissue. Several agar and one blood serum (beef) culture were also made. All remained sterile. The method of inoculation consisted in thoroughly scorching the uninjured capsule, making an incision through this scorched area with a flamed scalpel, a second at right angles to this with a fresh knife. From the latter incision bits of pulp were torn away with flamed forceps and transferred on platinum loops to the various culture tubes.

Case 3.—Cow died at 9 a. m., August 28, 1888, in Carroll County, Md. The autopsy was made by Dr. Farrington at 10 a. m. Some of the organs were placed in different compartments of a refrigerator pail specially constructed for this purpose, in which they were surrounded by a jacket of ice. The temperature of the air in the inner compartments varied from 32° to 40° F. No decomposition could thus begin, or continue if already begun, while the organs were kept in the pail packed with ice. Cultures were made from the various organs as soon as they reached the laboratory. The unbroken surface was thoroughly scorched and bits of tissue, etc., cut out from within this scorched area with sterile instruments.

The spleen is very large, pulp dark and disintegrated. Red blood-corpuscles do not appear altered. When stained with alkaline methylene blue on cover glasses the spleen pulp reveals no bacteria. Four tubes were inoculated with bits of the pulp, two containing bouillon peptone, two agar. After a week all sterile.

The liver is of a mahogany color, due to the accumulation of bile. When a bit of the liver tissue is crushed in salt solution and examined unstained under the microscope the liver cells themselves show their nucleus with five or six fat granules around it. Each cell is encircled by a narrow band of reddish-yellow material, forming a polygonal network and representing the bile canaliculi filled with inspissated bile. This peculiar injection is even visible on stained cover-glass preparations. It breaks up into straight and Y-shaped rods, indicating that it is solid in consistency. The rods are about 1.5 μ thick.

Sections of liver tissue (hardened in Müller's fluid and alcohol imbedded in chloroform paraffin and) stained in alum carmine, show a marked distention of the capillaries of the middle zone of the acini with red corpuscles. The bile canaliculi in the innermost and outermost zones appear as a yellow network. The nuclei of the cells of the innermost zone have become disintegrated, each appearing as a group of roundish granules. The middle zone shows degenerated and normal nuclei mingled together.

Blood corpuscles begin to crenate rapidly; in other respects no changes are manifest.

Cultures from the liver, three in bouillon peptone and two in agar, contain active growths on the following day. Nearly all contain the same motile bacillus. It is short, with rounded ends. In gelatin-roll cultures its colonies appear in the form of very thin, iridescent patches on the surface of the gelatin.

A portion of the large intestine contained lumps of hard feces. The mucosa was considerably reddened from the injection of minute vessels, especially on the summit of the longitudinal folds. Numerous roll cultures in gelatin were made from material scraped from the surface of the membrane. In most of these tubes the same

peculiar iridescent patches appeared, which consisted of short motile bacilli. Two mice and a rabbit were inoculated with the scraped material suspended in water. One mouse died in less than twenty-four hours. The spleen was enlarged to twice its normal size. A sero-sanguinolent œdema in the subcutis of thigh and abdomen. In cultures from the spleen, liver, and blood the same iridescent colonies developed as those obtained from the intestine directly in cultures. The second mouse died a few hours later. Local lesion as in the first mouse; spleen small. The same bacteria observed in the local œdema, but apparently absent from the spleen. An agar culture from the blood develops a rather thick, whitish, glistening growth of the same bacteria. The rabbit showed no ill effects after the inoculation.

From the kidney of the cow bits of tissue were transferred to bouillon peptone, agar, and gelatine. Of these five tubes one (agar) contains a feeble growth of small motile rods. The remaining four permanently sterile.

At the autopsy the bladder was empty, hence the condition of the urine could not be determined.

Material from this cow was brought to the laboratory in the refrigerator pail September 3, 1888. The spleen is about 8 inches wide in the middle and 1½ inches thick. The capsule is so tense that the softened pulp wells out wherever an incision is made and is so soft as to be readily broken up with a stout platinum loop. A bit of the pulp placed in salt solution, under the microscope shows immense numbers of apparently normal red corpuscles. No bacteria seen either in the unstained or the stained preparations. Four cultures made by adding bits of spleen pulp as large as split peas remain sterile. A gelatine roll culture contains but one liquefying colony.

Only a small mass of liver tissue brought for examination. It has a peculiar sickening but not putrefactive odor. The cut surface is yellowish. In salt solution the hepatic cells appear finely granular with nucleus distinct. Some contain fat globules and irregular masses of yellow pigment. The intercellular bile canaliculi are distended irregularly with yellow masses. The injection is not so uniform as in the preceding case. On stained cover-glass preparations no bacteria are visible.

Roll cultures of gelatine show that small bits of liver contain but few germs, as only two or three colonies appear in each tube. The germs of which they are made up are probably identical with those found in two liquid and one agar culture.

In the fourth stomach no lesions are perceptible. The duodenum is filled with brownish food-particles suspended in a thick liquid. The mucosa of the upper small intestine is covered with a yellowish white layer resembling in its consistency flour paste, and made up almost entirely of desquamated epithelial cells. The mucosa itself is injected in patches. Cover-glass preparations as well as roll cultures reveal the presence of the same germ found in previous cases. In fact it seems to be the only germ present in very large numbers. Two mice inoculated with some sterile water in which the pasty intestinal contents were suspended remained well. The gall bladder is moderately distended with a thick liquid containing in suspension flakes from 1 to 6 ^{mm} across, which are very numerous. This abnormal mass is free from bacteria according to microscopic examination and roll cultures. The urinary bladder had been ligatured at the autopsy. Specific gravity of the urine was 1020. It was yellowish red, slightly alkaline. The bladder contained a large deposit of amorphous salts of a pinkish hue, dissolving when heated. Tests showed the absence of bile pigments, sugar, and albumen. When the urine was removed the mucosa of the bladder near the neck showed a spot about 1 inch square covered with ecchymoses as large as pin's heads. In order to obtain cultures from the urine the wall of the bladder was burned through with a platinum spatula and the urine withdrawn with a flamed pipette. About ¼ cubic centimeter was added to a peptone bouillon culture, and a gelatine roll culture. One liquid culture became turbid, and a roll culture made from this revealed the fact that the germ was identical with the intestinal germ. The roll and the other liquid cultures remained sterile.

Case 4 (*steer*).—Dr. Curtice's notes are as follows: "This animal died September 2, about noon. The examination was undertaken about two hours later. Its temperature about one hour and a half before dying was 106°, taken at two separate trials. Its eyes were inflamed and whitened; after death their interior appeared opaque and yellowish. When first seen the animal was standing in the pasture; it had previously been lying down and had paroxysmal attacks, from one of which it afterwards died. The animal, though the flanks were tucked up, was moderately fat. The fat had an orange yellow tinge. The spleen was enlarged and tumid with blood of black-red color, and of blackberry jam consistency. The liver had a heavy waxy feel, and a decidedly yellowish color. The gall-bladder was normal in size and full of bile. The kidneys were overlooked. The urine was very high colored, but not bloody or wine-colored. The abomasum had some slightly reddened patches on the mucous coat; no ulcerations were seen. The rumen was impacted. The small intestine contained occasional dark spots about as large as the head of a lead pencil. The prominency of some portions of the villous surface was injected with blood, so that a reddened appearance was presented. The patches of inflammation were decidedly more abundant in the ileum than in the jejunum. The duodenum was blackened on its villous surface, and slight decomposition had set in. The odor was fetid. The lungs contained some blood spots, which appeared to have been made about the time of death. Some scattered lobules were collapsed. One side was emphysematous. The thoracic walls near the diaphragm were roughened as if from inflammation. The heart showed blood-red spots, which followed the direction of the muscles beneath the pericardium. These were more abundant on the left side toward the apex. Washed clots stained with yellow were found in each half. The surface of the lungs was stained yellow. The fauces were dark and inflamed, but this inflammation did not extend into the trachea."

Case 5 (*heifer*).—September 4. This animal died during the night. "The examination took place about 11 a. m., but the morning had been rainy and cold so that decomposition had not set in to any great extent. She carried a large number of ticks.

"The abdominal cavity contained rather more than a normal amount of serous fluid. This fluid was rather dark. One portion of the mesentery appeared as though there were some peritonitis present. The fat was of an orange yellow color. The spleen was enlarged, but the color was nearly normal. The liver had a yellowish cast; it was beginning to decompose on its concave surface, and more especially toward that part which was next the duodenum. The gall bladder was tumid and somewhat larger than normal. The left kidney was very dark colored (from decomposition (?)) on the outside, but apparently sound in the central portion. The bladder contained about a gallon of claret-colored urine. The omasum or manifolds was impacted. The abomasum or fourth stomach was normal. The left lung was normally contracted, but the right was full and spongy. It presented a yellowish tinge on section. The heart presented bright red spots underneath the epicardial serous membrane. These spots had their longest dimension in the direction of the muscles, and were more abundant in the left portion near the apex. There were clots in each side of the heart, and that on the left side was slightly washed. The pericardial sac contained an excess of reddish tinged fluid. The fauces presented but little inflammation."

The organs reached the laboratory September 5. The spleen shows the same enlargement as the former ones. The pulp is so soft that it wells out as a tarry black mass when the capsule is incised. No bacteria were detected on cover-glass preparations and three bouillon peptone tubes inoculated with spleen pulp remained sterile.

The liver was pale, emitting a slightly disagreeable odor. The acini appeared distinct and there was no injection of the bile canaliculi observable. In portions of the parenchyma a large bacillus had multiplied. Cultures remained sterile. The gall-bladder was distended with a very thick viscid bile scarcely flowing from the opened bladder. It holds in suspension rather coarse granules.

The duodenum is distended with brownish semi-solid food débris. The mucosa is swollen, shining, and discolored, but nothing is found pointing to severe inflammatory or hemorrhagic lesions. Roll cultures from its walls contain the same germ found in preceding cases. A loop of the small intestine had a slightly putrefactive odor; its contents were like those of the preceding case. The mucosa is swollen, glistening, deeply reddened in patches. The roll cultures reveal the same germ found in the duodenum.

The kidney presents no abnormal appearance excepting that the cortex has a dull washed-out appearance. One out of three (2 liquid, 1 agar) cultures inoculated with bits of tissue becomes turbid.

The urine brought in the ligated bladder has a dark wine-red color, but is clear. The specific gravity 1010, sediment slight; no red blood corpuscles could be seen. On boiling, a brownish scum rises to the surface and a flaky deposit settles to the bottom. Of three liquid cultures receiving in all 1 cubic centimeter of urine all remain clear.

Case 6 (*cow*).—"This animal died on the night of September 4. Her temperature, taken the forenoon before, was 103° F., but in the afternoon it was 106° F. This cow, like the other two, had the habit, during the last days of sickness, of pressing the head against the wall at times; she was very weak and showed some pain when lying down. The examination was made about 9 a. m. The carcass was but little if any decomposed. The spleen was enlarged, and had the blackberry jam appearance. This spleen showed a marbled appearance of the surface with the mottling, varying between the normal gray appearance and that due to the blood showing through the serous membrane. The liver seemed slightly enlarged and with a yellowish tinge, but this was not as marked as in No. 5. The gall-bladder and surrounding tissues were stained with bile. The fat was of the orange yellow tinge. The kidneys were enlarged and had acute congestion. The bladder was very full, over one gallon of dark claret-colored fluid being present. The fourth stomach had all of its mucous coat congested. The animal had been drenched the day before with Glauber salts, and this may have given rise to this appearance. The third stomach or manifolds was slightly impacted. The duodenum was black in the mucous coat. The small intestine had numerous small black spots along its length. The villous coat was reddened and in some places, more especially the ileum, blackened by inflammation. There had been some peritonitis indicated by the presence of considerable serum in the abdominal cavity. The lungs were normal; the extreme tip of the right was affected with worms (*Strongylus micrurus*)."

In this case the spleen was likewise exceedingly large, the pulp disintegrated so as to be readily scooped out with a platinum loop. It contains an immense number of apparently normal red corpuscles. Bacteria seemingly absent. Two liquid cultures made with pulp remain sterile.

The surface of the liver is smooth, the bile canaliculi not injected. The odor is disagreeable but not putrefactive. Throughout the parenchyma are spots of a more yellowish tinge from $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter. The discoloration is due to the active multiplication of a large anaërobic bacillus. Roll and liquid cultures from bits of tissue remain sterile. There is about 300 cc. of bile in the distended gall bladder. It is thick, of a dark amber color, holding in suspension small flakes. These flakes are covered with masses of bacteria and in roll cultures are found later on to be the same organisms obtained from intestines of preceding cases.

Sections of liver tissue hardened in absolute alcohol, imbedded in paraffin and stained in alkaline methylene blue (Löffler's) are peculiar in appearance. To the naked eye they appear mottled. Patches of unstained tissue are inclosed in an irregular meshwork of stained tissue, both summing up about equal in extent. Under a low power the unstained areas are quite variable in size and irregular in outline. They border upon the central vein of the lobule and evidently begin to form

there. Two or three such patches radiate from the center into different directions, some joining a patch form a neighboring lobule, others extending only a short distance. No lobule is entirely intact. Under a high power (Zeiss 2^{mm}. obj. ocular 4) the unstained areas show the cells faintly as yellowish masses of a finely granular character with a faint indication of the nucleus. The peripheral, stained areas show the cells with protoplasm very finely vacuolated (effect of the fatty degeneration?), the nuclei still distinct. In the capillaries are occasional clumps of yellow pigment evidently inclosed in cells.

In sections from another portion of the liver, which are stained in alum carmine, and in aniline water methyl violet, the necrotic areas are present only in a shallow zone under the capsule. The remainder of the section shows the same faintly vacuolated condition already referred to. In the alum carmine section the cell protoplasm is seen sprinkled thoroughly with very minute pigment granules. In the capillaries of all regions the Texas fever parasites are distinctly (methyl violet stain) seen within the red corpuscles which distend the lumen of the vessel. Each corpuscle contains apparently but one round coccus-like body stained blue (1892).

In 1889 several of the permanent cover-glass preparations of the liver were carefully reëxamined. In one preparation stained with gentian violet and decolorized with acetic acid, intraglobular bodies are distinctly visible, though present in very small numbers. In some corpuscles there were two bodies, in others but one. They appeared as round cocci stained blue in the uncolored corpuscle.

The mucosa of the fourth stomach is rather dark in color and contains very many small pits. The duodenum is filled with a dark-red thick liquid with putrefactive odor, probably bile. The membrane is swollen, glistening, dark red, owing to punctate and linear pigment spots closely set in the membrane. Portions of the small intestine were brought with ends tied. The mucosa covered by a dirty cream-colored pasty layer consisting of desquamated epithelium and molecular débris. Portions of mucosa have a deep wine-red color. Roll cultures made from the scrapings of the wall in these various situations contain the same germ found in o the intestines and in the liver.

Kidney, dark red; the surface presents minute blood-red points. All but the lip of the papillæ deeply congested. Ecchymoses in the pelvis. Of three cultures made from bits of tissue one becomes faintly clouded; the others remain clear. From the former a roll culture fails to develop. The ligated bladder contains about 1 quart of deep brownish red, slightly opaque urine; specific gravity, 1030. Sediment very slight. In it red blood corpuscles are still distinctly visible. The mucosa of the bladder has a pale-red appearance, probably due to the imbibition of hæmoglobin. Of three cultures made from the urine all remain sterile.

The microbe, isolated from the intestines of the four cases examined, and from the liver in two cases, was a saprophyte so far as its appearance and growth in culture media are concerned. It produces considerable turbidity in neutralized bouillon, with or without peptone, but there is no distinct membrane formed. The bacteria are motile, but their motility may be overlooked. In the hanging drop they appear quiet for a time, then one or more in the field of the microscope suddenly begin to move rapidly across the field, at the same time executing revolutions about that point as an axis where two are attached to each other. The peculiar bluish expansive colonies on gelatin, taken in connection with the other biological characters and the presence of these bacteria in the intestines of healthy cattle and other domesticated animals, identify them with the very common bacillus *B. coli communis*.

Inoculated into the small experimental animals this bacillus seems to exert no bad effect if the dose be limited. Large doses have not been tried, for the reason that some putrefactive bacteria which are known to be harmless may produce death when large doses are injected subcutaneously more by a kind of poisoning than by the actual infection of the organism with the injected microbes.

From an agar culture originally inoculated from a colony in a roll culture pre-

pared from the duodenum of No. 6, material was stirred up in sterile beef infusion until a cloudy suspension was obtained. From this—

Two mice received subcutaneously $\frac{1}{16}$ and $\frac{1}{8}$ cc.

Two rabbits received subcutaneously $\frac{1}{8}$ and $\frac{1}{4}$ cc.

One guinea-pig received subcutaneously $\frac{1}{4}$ cc.

All remained well.

The same negative results were obtained when cattle were fed with cultures of this germ.

September 5, 1888.—A flask containing 600 cc. of sterilized slightly alkaline bouillon was inoculated from a culture obtained from case No. 3 and placed in the incubator. On the second day the liquid was very turbid, of a pale straw color, with no perceptible membrane on the surface. On the bottom a small quantity of a flaky deposit. No putrefactive odor. On this same day a black heifer and a calf were drenched with the culture liquid, the former receiving 400 cc., the latter 200 cc. There was a slight elevation of temperature in both animals, which may have been due to other causes, however. Five days after feeding, the calf had quite a liquid diarrhea, but this disappeared in a few days. Both animals remained well.

October 15 five roll cultures in gelatin of the same germ were dried in watch glasses until the gelatin was very brittle. After drying eleven days a 2-year-old heifer was drenched with the dried gelatin cultures suspended in water. The feeding was followed by no symptoms of disease.

CASES OF TEXAS FEVER EXAMINED AT THE EXPERIMENT STATION AND THE PATHOLOGICAL LABORATORY OF THE BUREAU OF ANIMAL INDUSTRY, 1889–1892, INCLUSIVE.

No. 7 (native).—Black cow, 6 years old, has been on the station 2–3 years. Placed in field I* June 27, 1889, containing North Carolina cattle with ticks.

No symptoms of disease noticed until the middle of August, when she began to lose flesh rapidly, became dull, and refused to eat. Rumination ceased August 21. At this time she wandered aimlessly about or stood with head low and back arched. On the 22d very weak and scarcely able to walk. Disinclined to move except when urged, and standing most of the day in the bed of the stream passing through the yard. Dung passed in small quantities, which has a yellowish tinge and is coated with mucus. Color of urine not noticed. The mucous membrane of vagina dotted with hemorrhagic streaks and patches. Rectum not reddened.

August 23.—Found dead this morning. Ticks found on escutcheon (pubic region) and on hind limbs; few on fore limbs. Body greatly emaciated. The subcutaneous tissue of an abnormally deep orange color (jaundice).

Spleen very large, pulp dark and soft. Among the red corpuscles a considerable number have each a single round body within them readily brought out by aniline colors.

Kidneys deeply congested throughout the parenchyma. In the bladder about one quart of blood-red urine. When poured into a beaker it is entirely opaque and of a dark port-wine color. Specific gravity, 1022. When diluted with two parts of water in a test tube and held up to the light, it appears translucent and of a beautiful wine-red color. When boiled a slight quantity of a dirty brownish flocculent precipitate is formed.

The liver is enlarged, discolored, and on microscopic examination the bile canaliculi surrounding the hepatic cells appear as a yellow network; the cells themselves contain irregular masses of pigment. Many red-blood corpuscles contain the round stainable bodies. Bile, so thick that it scarcely flowed from the excised bladder, due to the presence of small yellowish flakes and plates.

Slight extravasation beneath endocardium and epicardium of heart. Lungs with a few old adhesions, otherwise healthy.

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* For diagram of the field for 1889, see Fig. 4, page 94.

In the digestive tract considerable congestion and pigmentation, chiefly on the summits of the longitudinal folds, extending from the duodenum with variable intensity as far as the upper portion of the colon.

The blood of this case was not studied during life excepting to count the number of red corpuscles July 11 and August 20. They numbered at the former date about 6,000,000 in a cubic millimeter, at the latter date about 4,000,000.

The temperature of this case rose on August 16–17 from 101.2 to 106.9 and remained high until death, August 23. (For the complete record, see p. 270.)

No. 8 (native).—Black heifer, aged 18 months, raised on the station. Placed in field I (containing North Carolina cattle with ticks) June 27, 1889.

August 26.—Animal has become gaunt and thin, walks as if hind limbs were weak. Vision seems impaired. The animal raises its forefeet quite high in walking and stumbles on inequalities of the ground. Refuses to eat to-day, although it ate yesterday. Wanders aimlessly about, preferring the bed of the stream. When standing the head droops and the back is arched.

August 27.—Animal lies down this morning and refuses to rise when urged to do so. At 8 A. M. stretched out at full length, lying quietly, apparently unable to raise the head. At 10 A. M. temperature 99.8° F. Pulse 80, irregular. Killed at 11.30 by a blow on the head.

Autopsy notes: Moderately emaciated. A few ticks attached to the udder and to the skin on pubic region. Jaundice absent. Spleen 18 inches long, 6 inches wide, and 1½ inches thick; pulp very soft and dark. Kidneys and urine very nearly like No 7; the urine perhaps even darker in color. The same condition of the liver and bile as in No. 7. Heart very flabby, left ventricle not firmly contracted. Small blood extravasations beneath epicardium of left ventricle and along interventricular grooves.

Digestive tract: Contents of third stomach rather dry and firm. In the fourth stomach a small quantity of very dry food. The mucosa considerably reddened. On the laminæ small erosions from the size of a pin's head to ¼ inch across, the base covered by a black (hemorrhagic?) scab. (These lesions were found in healthy cattle slaughtered for beef, and are probably wounds due to foreign bodies taken in with the food.) In the small intestine Peyer's patches are considerably infiltrated and raised above the general mucous surface. In the cæcum are lines of pigment about ⅛ inch in diameter. They continue about 12 inches below the valve. The remainder of the large intestine normal with the exception of a small hyperæmic patch in rectum.

The blood taken from a skin incision on the day and in the morning before the animal was killed showed a very small number of round intraglobular bodies, as a rule one in each corpuscle; in one corpuscle three were observed. The number of blood corpuscles before death was somewhat more than 5,000,000. In stained cover-glass preparations of the spleen pulp a considerable number of red globules contain the small round bodies, one in each cell usually between the centre and the edge of the corpuscle. Although various stains were used such as a watery solution of methylene blue, methyl violet and gentian violet, the alkaline methylene blue seems best. These bodies could be seen in the fresh pulp, spread in a thin layer between slide and cover-glass, as round, pale, sharply defined spots between centre and periphery of the corpuscles. After the spleen had been in a refrigerator thirteen days they were still visible.

The temperature of this case rose on August 23 to 103.4 and remained at this point until shortly before death, August 27. (For the complete record, see p. 270.)

No. 9 (native).—Bull, eighteen months old, raised on the station. Exposed in field I (North Carolina cattle with ticks), June 27, 1889.

August 26.—Blood, withdrawn from an incision through the skin, was dried and stained in an aqueous solution of methylene blue. In many red corpuscles, which are paler and larger than normal ones, from fifteen to twenty very minute stained

bodies of slightly variable dimensions are present, some not so large as the smallest cocci. Some corpuscles appear as if sprinkled over with these colored points (modified, embryonic red corpuscles).

August 30.—Blood withdrawn, and stained on cover-glass preparations in alkaline methylene blue shows a large number of red corpuscles containing five to ten stained coccus-like points. In a few red corpuscles are seen peculiar oval or pear-shaped bodies in pairs, lying parallel to each other. One end of the body is rounded, the other drawn out into a short terminal point.

August 31.—The animal died this morning. Mucous membranes and tissues quite pale; fat absent; no jaundice. Spleen 22 inches long, 6 wide, and 2½ thick in the middle. The pulp so soft that it almost flows out of the incised, tense capsule. Cover-glasses placed against the cut surface and then directly on the slide furnish a thin film of spleen blood in which about one out of every twenty-five corpuscles (4 per cent.) contains one or more parasites. They appear as circular, sharply defined pale spots, either centrally situated or nearer the periphery of the corpuscle. In a small number two are present in one corpuscle. They are about 2 μ in diameter when observed in the fresh state.

Kidneys resembling those of No. 8. In the blood therefrom the intraglobular bodies observed. The urine taken from the bladder is almost black when viewed in bulk. In a small test tube, viewed by transmitted light, it is of a deep port-wine color. Specific gravity, 1018. Reaction acid. A dirty brownish, flocculent precipitate, formed after boiling occupies about one-third of the liquid column after settling.

The liver presents the same appearance as in the preceding cases. Each liver cell is surrounded by a polygonal line of yellow cylindrical rods (bile pigment) representing the plugged bile capillaries. Nucleus of hepatic cells distinct. Among the blood corpuscles in the liver tissue nearly one-half contain the intraglobular bodies, resembling those found in the spleen.

Sections of liver tissue hardened in Müller's fluid and in alcohol and stained in various ways show no necrosis of tissue. The cells, however, contain much pigment in the form of minute granules. Large lumps are rare.

Bile very thick, containing the minute yellowish flakes already described.

Considerable extravasation on the epicardium of the ventral surface of the heart. The blood itself of a rather pale color clots very firmly. In the blood taken from the right ventricle perhaps one hour after death a very large number of intraglobular bodies could be observed. These are nearly round and quite invariably occur in pairs, being close together in the corpuscle. There are few corpuscles which have not thus been invaded by the parasites.

In the digestive tract the mucosa of the fourth stomach is normal with the exception of a few small hemorrhagic erosions. Feces in upper colon dry and hard. No other abnormal appearances noticed.

The temperature of this case rose to 106.7 August 15, fell to 102.2 August 19, rose again on August 22, and remained high until death. (For the complete record, see p. 270.)

No. 10 (*native*).—Calf, four months old, raised on the station. Exposed, June 27, 1889, in field I (North Carolina cattle with ticks).

August 31.—The animal died to-day, and was examined immediately after death. No emaciation; no jaundice. Spleen as usual very large, soft, and dark (13½ × 4 × 1½ inches). Urine contains no hæmoglobin; of normal color. Liver, however, very much enlarged, of a peculiar "mahogany" color and a rather sickening odor. The fluid which exudes from the cut surfaces has the color of bile. The bile canaliculi are shown completely occluded by an injection of yellowish bile pigment forming a meshwork enclosing the hepatic cells. Bile very thick, due to the presence of yellow flocculi.

The mucosa of the fourth stomach dotted with minute opaque white elevations, which, on closer observation, represent the swollen periphery of minute worm-pits

(*Strongylus Ostertagi*). A few erosions with hemorrhagic base near pylorus. In the duodenum the mucosa is quite deeply stained with bile. No lesions in the intestine.

In a preparation of heart's blood, taken one-half hour after death, a considerable number of intraglobular parasites are found. They are more or less pyriform in outline; very few round forms seen.

The temperature of this animal fluctuated more or less, but did not rise above 104.5 at any time. (For the temperature record, see p. 270.)

No. 11 (*native*).—Red calf, 4 months old, raised on the station. Exposed June 27, 1889, in field I (North Carolina cattle with ticks).

September 10.—Found at 2 p. m., lying down, unable to move. Respirations irregular, hardly perceptible. It was killed by a blow on the head and examined immediately.

Animal very much emaciated. Several ticks on inner surface of thighs. Spleen moderately engorged; pulp soft and dark. In preparations a very large number of corpuscles were seen with parasites within them. Probably not less than $\frac{1}{5}$ of the corpuscles invaded. Sometimes 2 bodies, very rarely 3 in the same corpuscle. They were the largest seen thus far. In form they are circular, and two, side by side, stretched almost across the diameter of the corpuscle. Kidneys but slightly congested in appearance. The urine has a port-wine color, which is not so dense as in most preceding cases. In a test tube it is translucent without requiring dilution with water. Reaction, alkaline. A dirty scum forms on boiling.

The liver is rather firm, nearly normal in color. Little or no injection of bile capillaries observed. The bile is somewhat more viscid than normally, but of normal color and containing very little flocculent matter in suspension.

The blood corpuscles in the liver are invaded by parasites in the same degree as those in the spleen. They are very distinct in fresh, unstained preparations. Occasionally a large body 2 to 2.5 μ in diameter is associated with a very small one in the same corpuscle.

Nothing abnormal in the stomachs and intestines. Duodenum bile-stained.

Temperature fluctuating between 103 and 104.5 much of the time from August 16 until a few days before death. (For complete record, see pp. 270 and 271.)

No. 12 (*Southern*).—Heifer, 2 years old; received June 27, 1889, from near New Berne, N. C., and placed in field I.

August 17.—Removed and sold.

No. 28 (*Southern*).—Cow, 5 years old; received June 27, 1889, from near New Berne, N. C., and placed in field II after the ticks had been picked off.

August 17.—Removed and sold.

No. 29 (*Southern*).—Cow, 7 years old; received June 27, 1889, from near New Berne, N. C., and placed in field II after the ticks had been picked off.

August 17.—Removed and sold.

No. 30 (*Southern*).—Heifer, 3 years old; received June 27, 1889, from near New Berne, N. C., and placed in field II after the ticks had been picked off.

August 17.—Removed and sold.

No. 32 (*Southern*).—Heifer, 2½ years old; received September 14, 1889, from New Berne, N. C. Placed in field II for remainder of season.

July 4, 1890.—Exposed in field VI (Southern cattle with ticks).

The blood was examined September 3. The animal became greatly excited while being caught. Temperature, 101° F; respiration, 60; pulse, 90. 5,875,000 red corpuscles in a cubic millimeter. In the blood no abnormal elements detected.

Urine collected at the same time. Color, light yellow; specific gravity, 1035; strongly alkaline. No albumen.

Animal remained in this field until November 3. Exposure without result. Only slight fluctuations of temperature (see pp. 277 and 278).

No. 35 (*native*).—Gray and white heifer, 2 years old; received August 16, 1889,

from St. Marys County, Md., and kept in field IV until September 14. On this day transferred to field III (Southern cattle with ticks).

The animal manifested no symptoms of disease during exposure. On November 5 the blood was examined and no abnormal elements observed. The corpuscles numbered 6,000,000. The animal was in very good condition. (For temperature record, see p. 272.)

No. 40 (*Southern*).—Steer, 3 years old; received June 27, 1889, from near New Berne, N. C., and placed in field I. Removed and sold August 17.

No. 41 (*native*).—Roan cow, 4 years old; received and kept with No. 35 until September 14, 1889. On this day exposed in field IV (Southern cattle without ticks).

On November 6 the blood was examined. No abnormal forms observed. The corpuscles numbered 6,520,000. (For temperature record, see p. 273.)

No. 42 (*Southern*).—Cow, 6 years old; received June 27, 1889, from near New Berne, N. C., and placed in field I (North Carolina cattle with ticks).

August 17—Removed and sold.

No. 43 (*native*).—Red steer, about 3 years old, from Charles County, Md. Placed in field I (North Carolina cattle with ticks) August 24, 1889.

September 10.—Urine collected to-day has a port-wine color. Reaction alkaline. Liberation of large quantities of gas when acidified. When boiled it remains clear until an acid is added, when a brownish flaky precipitate forms, which, after settling over night, is equivalent to about one-sixth of the column of liquid in test tube.

September 11.—Animal very weak towards evening, lying down most of the time. Continues in this condition for another day, and is found dead on the morning of September 13. Examined immediately.

Autopsy: On the surface of the heart some small blood extravasations. Small, firm, dark-red clots in both cavities of the heart.

Slight hypostatic congestion of the right lung; no lesions observable.

Spleen very large (21 × 7½ × 1½ inches), soft, dark-colored. In fresh and stained preparations of spleen pulp a moderate number of round, intraglobular bodies.

Liver of a yellowish color; the bile-canaliculi more or less occluded with cylindrical masses of yellow bile, as in preceding cases. There is also a considerable amount of fat in the hepatic cells. A preparation from the blood in the liver showed probably 10 per cent of the corpuscles infected with parasites. Bile contains a dense suspension of minute yellow flakes.

The bladder contains a liter of clear wine-colored urine without sediment; slightly acid; specific gravity, 1013. A precipitate forms with picric acid as well as on boiling.

The digestive tract normal, with exception of the duodenum, the mucosa of which is considerably pigmented and bile-stained. In the rectum the feces covered with mucus.

Cultures were made from this animal as follows:

A minute bit of spleen pulp was placed in four tubes containing respectively bouillon-peptone, blood serum (cattle), glycerin agar, simple agar. These tubes, kept under observation in a thermostat for several weeks, remained sterile.

Blood taken from the heart with pipette was added to tubes containing the same media, ½ cc. being used for each tube. These also remained sterile.

From the kidney bits of tissue were added to the same media. Two tubes contained subsequently a large bacillus with terminal spore; one contained a colony of yellow coccus, and one a colony of a large coccus. These were probably contaminations. (For the temperature record, see pp. 270 and 271.)

No. 44 (*native*).—Black and white steer, 4 years old, from Charles County, Md., placed in field I (North Carolina cattle with ticks), August 24, 1889.

September 13.—Urine observed to be tinged with hæmoglobin to-day (red water). It behaves towards reagents precisely like that from the preceding case, No. 43.

September 14.—Blood examined to-day, but nothing definite observed.

September 16.—Lies down most of the time and is slow to rise when urged to do so. Temperature gradually falling, 103° F. at 3 p. m. Cover-glass preparations of blood show a great decrease of red corpuscles (1,063,333 in 1 cubic millimeter). When stained in alkaline methylene blue and decolorized in 1 per cent acetic acid, a moderate number of red corpuscles slightly larger than normal forms are seen, containing from 5 to 10 stained granules.

September 17.—Animal died during the night and was examined this morning. Autopsy: Several large and small ticks on fore and hind limbs and escutcheon (pubic region). Mucous membranes and subcutaneous tissue very pale. No jaundice observed.

In right ventricle of heart a large dark clot; in left, a small one; both are very firm, almost like liver tissue. Lungs more or less œdematous. In the trachea a considerable quantity of pinkish-white foam.

Spleen is very large (20 × 6½ × 1¾ inches). The pulp more disintegrated than any thus far observed. It oozes out from the incision through the capsule as a semi-liquid dark-red mass. Intraglobular bodies in only a few blood corpuscles.

Liver: Color, yellowish. The bile canaliculi injected with solid bile. Large oil globules in liver cells. Bile, almost solid, owing to presence of mucus and flaky particles. It can be drawn out into long bands. No intraglobular bodies detected in several preparations from blood in the liver. Urine in bladder free from hæmoglobin, yellowish-red in color; reaction, acid; specific gravity, 1013. A flocculent albuminous precipitate appears on boiling equivalent to about one-tenth of the volume of liquid.

Digestive tract: The mucosa of fourth stomach near cardiac orifice is reddened in a punctiform manner. The small intestine contains a large quantity of turbid liquid. The duodenum and upper jejunum dotted with numerous pigment points. In the remainder of the small intestine, points and patches of ecchymosis, especially marked in the ileum. Contents of large intestine quite firm; in the rectum the feces in balls covered with mucus. The minute vessels of the mucosa injected.

A number of culture tubes were inoculated with blood from the heart in order to determine whether any one species of bacteria were present. From ¼ to ½ cc. of blood was added to each of three tubes of bouillon peptone, two of blood serum, and three of agar. In each of the agar tubes a large bacillus growing in long chains and producing gas was present. The same bacillus and a coccus present in one bouillon peptone tube, the remaining two clear. One blood serum tube remained sterile, the other contained a pigment coccus. Bits of spleen were placed in three tubes, two containing glycerin agar, the third bouillon peptone. One agar tube contained subsequently one colony of a coccus, the others remained clear.

The temperature in this case rose September 6, and remained high (104–107.2) until death. (For complete record, see pp. 270 and 271.)

No. 45 (*Southern*).—Cow 7 years old. Received June27, 1889, from near New Berne, N. C., and placed in field I.

August 17.—Removed and sold.

No. 46 (*native*).—Roan and white heifer 20 months old. Received August 20, 1889, from the District of Columbia and placed in field I (North Carolina cattle with ticks).

September 5.—Blood examined after the temperature had been high for four or five days showed a very few intraglobular bodies.

September 10.—Animal found lying down, unable to rise. Temperature 96.2° F., killed at 10 a. m. Blood taken immediately from some superficial veins showed very few intraglobular parasites.

Animal in good condition. On the pubic region a few small ticks. Fat of normal yellow color. Spleen very large (22 x 7 x 2 inches), pulp soft and dark. In preparations of the pulp, examined fresh and stained, about 2 per cent of the corpuscles contain one or two round bodies each. Liver weighs 12 pounds, affected as in previous

cases. Quite friable to the touch. The same injection of the bile canaliculi. Considerable fat in the hepatic cells. Very few blood corpuscles containing parasites. Bile very thick and viscid, resembles finely chewed grass.

Urine of a deep port-wine color, faintly translucent in a layer several inches deep.

Digestive tract: Greater portion of laminated part of the fourth stomach is of a bluish-pink color. On the laminæ a large number of dark depressed points, also small erosions with reddened periphery and larger slightly depressed areas to which are attached shreddy masses of a diphtheritic character. Pylöric portion of stomach and duodenum normal. In the remainder of the small intestine a considerable quantity of turbid watery liquid. No appearance of catarrhal inflammation. Peyer's patches slightly infiltrated. In cæcum and for 2 feet below valve the longitudinal ridges of the mucous membrane extensively pigmented. Near rectum, more or less hyperæmia.

Blood from the heart, examined soon after death, failed to show any intraglobular bodies.

The temperature of this case rose August 31 to 105 and remained high (105–107.3) until before death. (For complete record, see pp. 270 and 271.)

No. 47 (native).—Cow, aged 3½ years. Received September 4, 1889, from Prince George County, Md., and placed in field IV until September 14, 1889, when it was exposed in field III (Southern cattle with ticks).

November 11–15.—Has been growing thin quite rapidly, and very weak, especially in hind quarters. Dull and lying quietly most of the time.

November 15.—The blood was examined to-day and found very anæmic. Only 865,000 corpuscles in a cubic millimeter. Fully one-third are abnormal. They are, as a rule, larger than in health, from 7.5 to 8.5 μ in diameter. When dried and stained with methylene blue, the following forms are noted:

(1) Corpuscles showing on their disk a variable number of stained particles, from 0.3–0.4 μ in diameter. They number from 5 to 20 in a corpuscle.

(2) Corpuscles which have retained a diffuse stain.

(3) Corpuscles intermediate between these which have not only retained a feeble bluish tint but are beset with a large number of very minute stained points.

Besides these modified transitional forms of red corpuscles, about 5 per cent of the total number have on their periphery a very minute well-stained body from 0.3 to 0. 5 μ in diameter (Texas fever parasite).

November 16–30.—Its condition has been slowly improving but it is still emaciated.

December 2.—Blood again examined. Now 3,126,000 corpuscles in a cubic millimeter. The various transitional forms and the parasites have disappeared. The only abnormal condition still prevailing is a variation in the size of the red corpuscles. Some are still over 8.5 μ in diameter.

August 21, 1890.—Continued to improve slowly during the winter and is now in only fair condition. Exposed to-day in field VIII (ticks only).

September 5.—Temperature 106; respiration 42; pulse 60. Red corpuscles 3,916,666 in a cubic millimeter.

September 8. Very sick and emaciated. Transferred to field IV (sick natives only).

September 12.—Died quite suddenly at 9 a. m. The blood had not been examined since September 5.

Autopsy notes: Animal in rather poor condition. Weight about 600 pounds. A considerable number of half-grown ticks on the inner side of thighs and on escutcheon. In abdominal cavity nothing abnormal. Heart large, considerable fat on pericardium and around base. Ecchymoses under the epicardium of the left ventricle, fewer on right ventricle. In right heart a large, dark clot extending into the venous trunks. A large clot of the same character in the left side. Groups of fibers of the heart muscle show fatty degeneration. Interlobular emphysema in left ventral and principal lobes. Slight vesicular emphysema of right cephalic lobe.

Spleen weighs 2¾ pounds. Pulp dark-brownish in color; no disintegration. Malpighian bodies still visible on section. Engorgement slight.

Liver weighs about 13 pounds, of a uniform yellowish brown color on section. In thin sections of the fresh organ, complete yellow injection of the bile canaliculi and of some of the smallest ducts observed. Considerable yellowish pigment within the hepatic cells. Very little blood in capillaries. Fatty degeneration slight.

Sections of liver tissue (hardened in Müller's fluid, embedded in chloroform paraffine and stained in Ehrlich's hæmatoxylin) show the same intermingling of stained and nearly unstained areas mentioned under No. 6. The unstained areas equal together perhaps one-quarter of the whole area of the section, and are isolated. They radiate from the central vein. Within them neither the cells nor the cell nuclei are any longer visible as such. The connective tissue nuclei not increased in number. On the border of these patches are zones of bile injection. Red corpuscles are not seen.

In the gall bladder about 6 ounces (180 cc.) of dark green bile containing a large quantity of flakes, and hence very thick.

Kidneys embedded in much fat; not surrounded with any œdematous tissue. On section, the cortex brownish-red; congestion slight. Pigment in epithelium of the convoluted tubes in small masses. Bladder contains about 2½ quarts of claret-colored urine. The hæmoglobin slight in quantity. Reaction barely alkaline. Specific gravity 1015. Abundant flocculent precipitate after acidifying and boiling.

In the rumen, contents dry and in lumps. Third stomach normal. In fourth stomach contents as in the rumen. On the laminated portion, a small number of irregular scars or erosions with hemorrhagic base. Injection of the minute vessels in spots. Duodenum with mucosa pale, not bile-stained. In the ileum mucosa normal, contents of a greenish-yellow color, with a fecal odor, and undergoing fermentation. Cæcum empty, normal. In colon and rectum, large, firm balls of fecal matter. Mucosa, normal.

Cover-glass preparations of the various organs, dried and strained, were examined with the following results:

In blood from the right heart infected corpuscles very rare. In the spleen only one-half to 1 per cent of the corpnscles contain the parasite. Each infected corpuscle contains two round or slightly elongated bodies 1 to 1.5 μ in diameter, situated near the center.

In the liver, between 5 and 10 per cent of the corpuscles infected. In one, four parasites observed. Diffusely stained corpuscles, indicating a beginning regeneration of the blood corpuscles, present in small numbers; also some hæmatoblasts.

In the kidney, not less than 20 per cent of the corpuscles contain twin parasites. There are present a very large number of free bodies which, from their form, size, and staining, are evidently parasites, the corpuscles once containing them having been broken up. (For the temperature record, see pp. 272, 281, and 282.)

No. 48 (native).—Red and white heifer, aged 3 years. Received August 14, 1889, from Montgomery County, Md.

September 14.—Placed in field V (cattle ticks only).

October 20.—Loss of appetite first discovered to-day. Animal in a dumpish condition.

October 21.—Very weak, can scarcely walk. Blood taken from a skin incision contained only 1,285,000 red corpuscles in a cubic millimeter. It clots quickly and firmly. It was thought best to kill the animal, as it did not seem likely that it would live until next day. Killed by a blow on the head.

Spleen large, engorged (22 inches long, 6½ wide at widest portion). Only a few infected red corpuscles detected in fresh preparations. A large number of masses of yellowish pigment in irregular clumps from 2 to 8 μ in diameter. When spleen pulp dried on cover-glasses and stained in alkaline methylene blue about 10 per cent of all the red corpuscles in the field contain each a minute spherical stained body,

not more than $\frac{1}{2}\ \mu$ in diameter. Rarely two are present in one corpuscle, and then so near together that they can scarcely be distinguished. They are situated near the periphery, a few on the very edge of the corpuscle and seemingly attached to, not within, the corpuscles. The pulp contains also a large number of large corpuscles and a small number of hæmatoblasts.

Liver enlarged, edges rounded. Surface everywhere mottled with minute irregular yellowish patches. This appearance also on section. The parenchyma examined microscopically in fresh sections in several places does not show any biliary injection. The hepatic cells contain variable numbers of oil globules. A small number of intraglobular parasites observed after staining.

In the blood of kidneys which appear normal, very few intraglobular parasites. Urine of a pale yellow color, clear. Reaction acid. Specific gravity 1018. Albumen absent.

In the fourth stomach over cardiac half, many little pits due to *Strongylus Ostertagi*. Mucosa otherwise normal. The mucosa of duodenum and upper jejunum covered with a semiliquid layer, which has a deep yellow color. Mucosa of ileum more or less bile-stained. Peyer's patches infiltrated. Large intestine normal. Uterus contains a fœtus four months old.

Cultures were made at the autopsy by adding a trace of blood and spleen pulp to tubes of agar and agar containing glycerin, both acid and alkaline. No growth in any tube. (For the temperature record, see p. 273.)

No. 49 (native).

[Heifer, 3 years old. Received Aug. 16, 1889, and kept with Nos. 35 and 41 until Sept. 14, when it was transferred to field III (North Carolina cattle with ticks). No indication of disease. Calved Feb. 15, 1890. July 4, 1890, exposed with calf No. 85 in field VI (North Carolina cattle with ticks).]

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature record, see pp. 277, 278.)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.	°			
Aug. 21, 1890	4,865,000	Some large parasites.	....	Normal	Normal	106.7	88	48	Removed to-day with calf to field IV (sick natives only). Urine and feces normal.
Aug. 22, 1890	3,579,000	Some bright bodies.	Some large parasites.	....do	....do	106.9	96	63	Losing flesh rapidly.
Aug. 23, 1890	3,162,000	Negative	Negative	....do	....do	105.7	90	45	Urine free from hæmoglobin; sp. gr. 1022. Albumen 0.05 per cent.
Aug. 27, 1890	3,050,000	....do	Some large parasites.	Some macrocytes.	Punctated and tinted corpuscles.	101.5	90	45	
Sept. 4, 1890	2,213,000	Large parasites...	10 per cent large parasites.	....do	....	103.8	84	60	Urine has a deep port-wine color. Sp. gr. 1030. Alkaline. Albumen present. Sept. 5, urine contains less hæmoglobin. Sept. 6, urine free from hæmoglobin.
Sept. 2, 1890	3,800,000	A few bright bodies.	Some large parasites.	Many macrocytes.	....	102.0	90	54	
Sept. 18, 1890	4,400,000	Many bright, rod-like bodies.	Negative	....do	....	102.4	....	.....	Urine pale, watery. Sp. gr. 1013. Otherwise normal.
Sept. 30, 1890	2,671,000	Some bright, rod-like bodies.	....do	Some macrocytes.	....	100.6	78	24	Urine free from abnormal constituents. Sp. gr. 1040.
Oct. 7, 1890	3,521,000	Negative	Negative	Many macrocytes.	....	101.0	90	24	
Oct. 14, 1890	3,722,000	Some pale, rod-like bodies.	5–10 per cent peripheral cocci.	....	....	101.6	84	42	Bowels rather loose. Odor of feces disagreeable.
Nov. 8, 1890	4,303,000	....do	Negative	....	....	......	...	....	
Nov. 19, 1890	4,920,600	Negative	....do	Normal	Normal	103.4	80	40	Dec. 1. This animal began to lose flesh Aug. 21, and continued to do so until Sept. 5, at which time it was very weak. Since then it has been gradually recovering and has now almost regained its original weight. Temperature very high from Aug. 18 to Aug. 23.
Nov. 13, 1891	5,872,000 (white 16,363)	....	....do	....do	....do	103.2	72	48	Not exposed. In field XII during the summer.

No. 50 (*native*).—Red and white cow, Jersey grade, aged 3 years. Received with calf No. 97 August 20, 1889, from Montgomery County, Md., and placed in field V. Transferred, with calf, September 14, to field IV (Southern cattle without ticks). No elevation of temperature was noted. The blood was examined twice:

November 7.—Red corpuscles, 6,220,000. No abnormal forms detected.

November 15.—Red corpuscles, 6,044,000. No abnormal forms detected.

April 9, 1890.—Calved to-day.

July 4, 1890.—Exposed, with calf 79, in field VI (Southern cattle with ticks).

September 3.—Animal very sick. Has grown very thin lately. A large number of ticks, including adults, attached to skin. Transferred to field IV. Blood examination showed only 1,127,000 corpuscles in a cubic millimeter. A moderate number of corpuscles are infected, the parasites being either single or in pairs. A few corpuscles contain the minute bright bodies. The extreme anæmia is manifested by the presence of large corpuscles which stain diffusely or contain stained granulations, also a small number of hæmatoblasts. These are quite small compared with the hæmatoblasts of other observed cases. The nucleus is either partially extruded or else within the corpuscle near the periphery.

September 6, 9 a. m.—The animal is exceedingly weak. Temperature, 99; respiration, 24; pulse, 84. It is unable to rise and groans slightly with each expiration. Dies at 1.30 p. m.

Before death the blood was carefully examined. The hæmatoblasts were increased in number. A small number of intraglobular parasites, some of which manifest changes in form on the warm stage at 35° to 40° C. The changes follow each other so rapidly that it is impossible to sketch all consecutive stages. Some corpuscles also contain the bright bodies. In stained preparations very few corpuscles appear normal. The larger number are either diffusely stained or dotted with stained granules or else represented by infected corpuscles and hæmatoblasts.

Autopsy notes: Body emaciated. To the skin adhere a large number of ticks of various stages, mature forms predominating.

Lungs normal. Emphysema on the right side of the right principal lobe. Right side of heart greatly distended with still fluid blood. The left side also distended. The usual subepicardial ecchymoses over the entire surface of both ventricles and on fatty tissue around the base.

Spleen weighs 4½ pounds. Quite firm to the touch, the Malpighian bodies distinctly visible on section. The organ is but slightly changed. In it a considerable number of hæmatoblasts and hæmatoblast nuclei. Intraglobular parasites rare.

Liver weighs 12½ pounds. It is manifestly enlarged, the edges rounded, the whole firm to the touch. The surface mottled with minute yellowish patches. On section, the color is yellowish brown, and on closer inspection the minute patent vessels are seen sheathed with brighter yellow zones. (Plate II, Figs. 1, 2.) The bile capillaries are quite generally injected with bile; the hepatic cells themselves have undergone fatty degeneration. Many hæmatoblasts present. In the gall bladder about 16 ounces of thick, dark bile loaded with a large quantity of solids.

The kidneys are paler than normal, the cortex brownish, the pyramids near the base whitish. Under the microscope the epithelium generally is found filled with pigment granules. The tubes of the pyramids filled with fat globules. In sections from material hardened in alcohol and stained in hæmatoxylin and alum carmine no pathological changes detected.

The urine taken from the bladder (about 8 ounces) slightly tinged with hæmoglobin. It is faintly alkaline, and contains a small quantity of albumen. Specific gravity 1012. On standing, slight deposit of urates.

The digestive tract is normal as a whole. The rumen fairly well filled, the manifolds with contents dry and firm. The mucosa of the fourth stomach normal, with the exception of minute nodular swellings containing a central perforation (*Strongylus Ostertagi*).

In the small intestines nothing abnormal. The large intestine also intact. In the cæcum the feces yellowish brown; in the rectum a few hard balls.

In the spleen, liver, kidneys, and marrow the intraglobular parasites correspond both in number and character with those found in the blood before death. In the kidneys there are in addition an immense number of free forms.

The temperature of this case was high from August 25 to September 1, inclusive. (For the complete record, see pp. 273, 277, and 278.)

No. 51 (*native*).—Brindle cow, 3 years old, received June 27, 1889, from Maryland. Placed in field II (North Carolina cattle without ticks). No result up to September 14. On this day fresh North Carolina cattle with ticks were put into this field, No. 51 remaining there.

October 28.—Quite weak and refuses to eat. Losing flesh rapidly.

October 29, 30.—Weakness and emaciation much more pronounced, so that it seemed as if she were going to die.

October 31.—Slight improvement. Appetite begins to return.

November 4.—Animal in very poor condition. Blood examined to-day; corpuscles down to 1,330,000. There are present a large proportion of red corpuscles which stain diffusely and which contain stained granules. White corpuscles evidently increased in number, some of them probably identical with free hæmatoblast nuclei. A small number of corpuscles infected with parasites. These appear in the form of peripheral coccus-like bodies.

Throughout November improvement gradual. Her lost flesh not entirely regained.

The blood of this animal was not examined again until June 18, 1890. The corpuscles at this date were normal and numbered over 6,000,000 in a cubic centimeter.

July 4, 1890.—Reëxposed in field VI (North Carolina cattle with ticks).

August 21.—Temperature 107; respiration 60; pulse 78. Number of corpuscles 5,125,000, When examined unstained, a small number of corpuscles contain each one, rarely two bright bodies, very minute. In stained preparations nothing abnormal observed.

August 26.—Animal found unable to rise this morning; expiration accompanied by a slight groan. Temperature 95.5; respiration 30; pulse 42, very feeble. Blood corpuscles 2,730,000 in a cubic millimeter. A small number contain large parasites; a considerable number contain the bright points, many in active motion. In stained preparations nothing else observed.

Dies at 11 a. m.

Autopsy notes: Weight about 500 pounds. A moderate number of ticks on inner surface of thighs, escutcheon, and neck. Muscular tissue normal. Patches of extravasation in subcutis over sternum probably due to ante mortem position. On serous covering of rumen a small number of calcified tubercles. Similar ones on costal pleura.

Lungs normal. Calcified tuberculous nodules in bronchial and mediastinal glands. Considerable ecchymosis under epicardium of the left ventricle and on the right near interventricular groove. Blood clots readily and firmly. Sarcosporidia cysts very abundant under endocardium of both ventricles. They are up to $\frac{1}{2}$ ^{mm} long and from $\frac{1}{2}$ to 1^{mm} apart. Under endocardium of left ventricle near septum, and of right auricle some ecchymotic patches. Heart muscle in state of fatty degeneration.

Spleen weighs $5\frac{3}{4}$ pounds. On the convex surface about six partly calcified tuberculous nodules $\frac{1}{4}$ inch in diameter. Spleen very much engorged. On section the pulp is of the usual dark brownish red (blackberry jam) color, very soft and almost wells out; trabeculæ and Malpighian bodies not visible. A large number of the large granular cells (22 μ) contain from 1 to 12 red corpuscles.

Liver greatly enlarged, weighing 19 pounds. Weight in part made up by large tuberculous glands about the portal fissure. Small tubercular masses disseminated throughout the liver tissue, especially abundant in small lobe. Parenchyma has a

yellowish-brown color. Under the microscope this color is found due partly to the advanced fatty degeneration of the cells, partly to the yellowish masses of pigment within the cells.

Bile so thick from admixture of amorphous solids that it scarcely flows from the incised bladder.

The fatty tissue around both kidneys, especially the left, in a condition of sanguinolent œdema. More or less congestion of the entire parenchyma. Minute petechiæ in cortical substance. In sections of fresh tissue the capillaries are seen filled with dense masses of blood corpuscles, in some of which the parasites may be distinguished. Urine pale, free from hæmoglobin. Specific gravity 1015. Neutral. Albumen present in small quantity.

In stained preparations of kidney, liver, and spleen a small number of red corpuscles are found invaded by large paired parasites.

The digestive tract normal with following exceptions: Contents of manifolds somewhat dry. On mucosa of fourth stomach a few slightly depressed ecchymoses. In duodenum *Dochmius* present. In the ileum worm-nodules of various sizes under mucosa. Very little dry feces in large intestine. Mucosa shows occasional ecchymoses. (For the temperature record, consult pp. 272 and 277.)

No. 52 (*native*).—Bull calf of No. 51, aged 4 months. On June 27, 1889, placed in field II (North Carolina cattle without ticks) with No. 51. No result up to September 14. On this day North Carolina cattle with ticks were put in field II, in which No. 52 remained.

October 29–November 11.—Calf during this period very sick, as manifested by marked emaciation, weakness, and loss of appetite.

November 7.—Blood contains 2,219,000 corpuscles in a cubic millimeter. There is considerable variation in their size, some having a diameter of 9 μ. When stained, a small number (perhaps 1 to 2 per cent) are observed with the peripheral coccus-like bodies.

November 11.—After this date slow improvement. Unthrifty and stunted condition of calf through the winter. (For the temperature record, see p. 272.)

No. 53 (*native*).—Heifer, 18 months old, raised on the station. Placed in field II (North Carolina cattle without ticks) June 27, 1889.

September 6.—There being no result up to date, the animal was transferred to field I (North Carolina cattle with ticks).

October 4.—Has been losing flesh during the past week and is now very weak and thin. Can not walk without staggering. Blood examined and found quite thin. Only 2,766,666 corpuscles in a cubic millimeter. In stained coverglass preparations the red corpuscles vary in size; some are quite large and show a large number of stained points on the disc, as if dusted over with granules of coloring matter.

October 10.—Slight improvement in the general condition since October 4. Blood examined to day. Only one intraglobular coccus-form seen, while there are a small number of the punctate corpuscles, described above, present. In one cubic millimeter of blood 2, 626,666 corpuscles present.

November 7.—Blood examined. About 3,560,000 corpuscles in one cubic millimeter. In preparations stained in alkaline methylene blue there are in perhaps 10 per cent of the red corpuscles barely visible coccus-like bodies, quite invariably on the periphery of the corpuscle, often on the very edge, one in each corpuscle.

November 11.—General condition has remained unchanged during the past month. Still weak and thin. Gives birth to a 6½ months' fœtus.

December 2.—Blood examined, but no abnormal forms detected. In one cubic millimeter about 3,080,000 red corpuscles. Slight general improvement. Animal still very thin. Appetite has returned.

April 1, 1890.—Improvement slow during the winter. Now in fairly good condition,

July 4.—Now in fine condition. Exposed in field VI (North Carolina cattle with ticks).

October 15.—Temperature, 101; pulse, 78; respiration, 33. A few ticks on animal. To-day is the only time the blood was examined. Corpuscles normal; 4,836,000 in a cubic millimeter. Urine passed during the examination was pale yellow. Specific gravity, 1040. Reaction strongly alkaline. No albumen.

(For temperature record, see pp. 271, 272, 277, and 278.)

No. 54 (*native*).—Red heifer, 2 years old, from Maryland. Placed, June 27, in field II (North Carolina cattle without ticks).

September 6.—Apparently no result up to date. Transferred with No. 53 to field I (North Carolina cattle with ticks).

September 20.—The heifer is lying down and rises only when urged. Led with difficulty to the laboratory. The temperature has fallen to 101.2 F. Animal killed by a blow on the head at 1 p. m., when it seemed quite certain that she would not live through the night. Shortly before death the blood was examined fresh, with and without salt solution, as well as stained in alkaline methylene blue. A small number of red corpuscles were found containing the micro-parasite. At the same time the corpuscles were counted and found to number 1,075,000.

Autopsy notes: On udder and pubic region a moderate number of ticks.

Spleen very large and engorged; 22 inches long and 7 inches across the widest portion. The pulp is very soft, though not yet disintegrated. Many of the red corpuscles contain the parasites, chiefly in pairs and having the form of an apple-seed. The two bodies are, as a rule, close together, parallel, slightly diverging, or end to end.

On the epicardium of the heart, ecchymosis limited chiefly to the left ventricle. Respiratory organs normal.

Fourth stomach shows a few superficial erosions of the mucosa, with hemorrhagic base. Duodenum and upper jejunum bile-stained. Mucosa of small and large intestines normal.

The liver but slightly discolored, and scrapings examined fresh under the microscope show very little injection of the bile capillaries. Bile holds no solids in suspension although the color is very much deepened. In blood from the liver a large number of intraglobular bodies seen, both in fresh and stained preparations. They also occur in pairs, some being round, some having the apple-seed form. The individuals of each pair are, as a rule, of the same size, although this is not invariably true.

Kidneys on section are of a dark red color. The urine is of a dark wine color and quite opaque, although it holds no solids in suspension; reaction acid. On boiling, a brownish flocculent scum rises to the surface. In blood from the kidneys a very large number of red corpuscles contain the parasites, quite invariably in pairs, as in spleen and liver.

From the organs a number of cultures were made in different media. Three inoculated with blood, and four with bits of spleen pulp, remained sterile. In a bouillon tube of the blood a small streptococcus appeared. In a bouillon peptone tube inoculated with a bit of liver tissue a diplococcus appeared. In a glycerin agar tube no development took place, while in a blood serum tube a small oval coccus grew. In cultures made from the kidney various germs appeared, such as a streptococcus, a vibrio, and a small coccus. These were probably mainly contaminations from the air, as the cultures were prepared at the station, where opportunity for contamination is favorable. (For the temperature record, see pp. 271 and 272.)

No. 55 (*Southern*).—Heifer; age, 3½ years; from near New Berne, N. C., received September 14, 1889, and placed in field IV after ticks had been picked off.

July 2, 1891.—Kept in stock since 1889, but not exposed to Texas fever in 1890.—On this day exposed in field VI (North Carolina cattle with ticks).

August 29, 1891.—Temperature, 102.1; pulse, 72; respiration 54. Red corpuscles, 5,103,000. Nothing abnormal in fresh or stained preparations.

October 20.—No result from this exposure. (For temperature record, see p. 286).

No. 56 (native).

[Steer, $2\frac{1}{2}$ years old, received from Maryland, September 14, 1889, and exposed in field II (North Carolina cattle with ticks) and other fields subsequently.]

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature record, see pp. 272, 280, 286, and 290.)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.	°			
Nov. 7, 1889	6,040,000	Negative	Negative	Normal	Normal				
Dec. 2, 1889	5,422,000	do	do	do	do				No symptoms of Texas fever up to date; slight loss of flesh.
Sept. 8, 1890									Reëxposed in field VI (North Carolina cattle with ticks).
Sept. 20, 1890	6,844,000	Some bright bodies	Negative	Normal	Normal	100.8			A few small ticks on animal.
Sept. 22, 1890	5,640,000	Many bright bodies	do	do	do	106	72	60	
Sept. 29, 1890	5,307,000	A few bright bodies	do	do	do	102	72	36	
Oct. 9, 1890	5,436,000	do	do	do	do	101.6	72	54	One mature and several small ticks on animal.
Oct. 22, 1890	4,666,000	Many bright bodies	10 to 20 per cent peripheral cocci.	do	do	102.3	54	30	
Oct. 25, 1890	2,754,000	do	do	do	do	103	60	24	
Oct. 30, 1890	2,720,000	do	do	Many macrocytes	Some punctated corpuscles.	101.7	72	36	
Nov. 6, 1890	2,344,000	do	20 to 30 per cent peripheral cocci.	30 per cent macrocytes.	10 to 20 per cent tinted corpuscles.	104.1	60	54	
Nov. 8, 1890	1,984,800	do	30 per cent peripheral cocci.	do	do	104	81	96	No ticks can be detected; steer dull and losing flesh slowly.
Nov. 10, 1890		20 per cent bright bodies.	do			104.2	90	96	Feces yellow; bright intraglolular bodies appear a little larger than before, oval in outline.
Nov. 13, 1890	1,183,000	5 per cent bright bodies.	10 per cent peripheral cocci.		Some hæmotablasts.	103.2	81	41	
Nov. 15, 1890	1,534,000	15 to 20 per cent bright bodies.	do	20 per cent macrocytes.	10 per cent punctated and 5 per cent tinted corpuscles	101.9	84	78	
Nov. 17, 1890	1,655,000	1 to 2 per cent bright bodies.	1 to 2 per cent peripheral cocci.		5 per cent punctated and tinted corpuscles.	101.5	68	36	
Nov. 21, 1890	2,615,000	A few bright bodies	A few peripheral cocci.			102.7	72	36	
Nov. 26, 1890	3,880,000	do	Negative			101.8	72	36	

No. 56 (native)—Continued.

[Steer, 2½ years old, received from Maryland, September 14, 1889, and exposed in field II (North Carolina cattle with ticks).]

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks.
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.	°			
Nov. 28, 1890	....	A few bright bodies ..	One pair large parasites. (Plate VI, Fig. 4.)	....	....	....	....	....	Has lost largely in weight; now improving.
Dec. 2, 1890	4, 706, 000	....	Negative	Some macrocytes .	=*	102. 2	68	40	
Dec. 11, 1890	4, 603, 400	....	1 per cent peripheral cocci.	....do	=	103	76	48	December 31. Recovery complete so far as outward appearances go.
July 2. 1891	....	....	....	....	....	....	....	....	Reëxposed in field VI (North Carolina cattle with ticks).
Aug. 26, 1891	3, 242, 000	Negative	Negative	Normal	Normal	106. 8	68	38	
Sept. 1, 1891	3, 553, 000	......do	....do	Many macrocytes.	=	103. 2	60	54	
Sept. 12, 1891	3, 264, 000 (white 9,434)	Several pairs of large parasites.	....do	...do	=	101. 2	66	54	Many ticks on animal.
Oct. 13, 1891	4, 687, 000	......do	....do	....	....	101. 2	96	36	
Aug. 26, 1892	6, 687, 500 (white 15,000)	....	....do	Normal	Normal	101. 4	60	60	Reëxposed in field VI (North Carolina cattle with ticks).
Sept. 8, 1892	5, 125, 000 (white 6,250)	....	....do	Slight variation of size.	=	102. 6	76	48	
Sept. 21, 1892	6, 365, 000 (white 8,750)	....	....do	Normal	Normal	101. 2	84	24	Probably a slight attack.

* See page 158.

No. 57 (*native*).—Cow, 9 years old, from the District of Columbia, received August 31, 1889. September 14, placed in field I (North Carolina cattle with ticks).

November 5.—The blood is normal. Corpuscles, 6,089,000 in a cubic millimeter. No abnormal or enlarged forms detected.

May 16, 1890.—Cow in good condition. Blood corpuscles normal; 6,662,000 in a cubic millimeter.

July 4.—Reëxposed in field VI (North Carolina cattle with ticks).

September 20.—A small number of ticks on animal. Some matured. Blood corpuscles normal; 5,362,000 in a cubic millimeter. In one corpuscle a motile bright body detected. (The only native which has resisted midsummer exposure.) For temperature record, see pp. 271, 277, and 278.

No. 59 (*Southern*).—Cow, age 4 years, from near New Berne, N. C., placed in field IV, September 15, 1889, after ticks picked off.

July 4, 1890.—Placed in field VI (North Carolina cattle with ticks) to test insusceptibility.

September 3.—Temperature, 103; pulse, 80; respirations, 42. Corpuscles, 6,313,-000. In fresh preparations a small number of corpuscles, several in a single field, contain the bright bodies.

No result from this exposure. (For temperature record, see pp. 277 and 278.)

No. 60 (*Southern*).—Cow, aged 4 years, from New Berne, N. C. Received September 15, 1889, and placed in field III.

September 1, 1891.—This cow has been kept in stock since 1889, but not exposed to Texas fever. On this date exposed in field VI (North Carolina cattle with ticks).

September 1.—Temperature, 102; pulse, 84; respiration, 48. A few ticks on animal. Corpuscles, 5,470,000. Nothing abnormal in fresh and stained preparations.

October 9.—Temperature, 101.5; pulse, 60; respiration, 40. Red corpuscles, 4,984,-000; white, 15,625, or 1 to 319 red. No abnormal forms observed.

October 20.—No result from this exposure although ticks just as abundant on this animal as on natives. (For temperature record, see p. 286.)

No. 61 (*Southern*).—Red steer, 18 months old; received September 15, 1889, from near New Berne, N. C., and placed in field II.

July 4, 1890.—Exposed in field VI (North Carolina cattle with ticks).

November 3.—No result. (For temperature record, see pp. 277 and 278.)

No. 62 (*Southern*).—Heifer, 18 months old, received from near New Berne, N. C., September 15, 1889, and placed in field III.

September 25, 1890.—Exposed in field II (Texas cattle with ticks).

October 15.—Temperature, 101.4. Corpuscles, 5,444,000. No abnormal forms.

October 22.—Temperature, 102.2; pulse, 72; respirations, 24. Corpuscles, 6,333,000. Several bright intraglobular bodies.

October 30.—Temperature, 102.5; pulse, 66; respiration, 18. Corpuscles, 5,695,000. A considerable number of bright intraglobular bodies from such as are barely visible (x500) to those $\frac{1}{2}\,\mu$ in diameter; all sizes motile.

On this date she was placed in a barn artificially heated and kept there until December 12.

July 2, 1891.—Placed in field VI (North Carolina cattle with ticks.)

October 20.—No result from exposure. (For temperature record, see pp. 275, 284, and 286.)

No. 63 (*Southern*).—Cow, 3½ years old, received September 15, 1889, from near New Berne, N. C., and placed in field IV after the ticks had been picked off.

November 5.—General condition very poor. Corpuscles, 5,540,000.

December 9.—This animal was killed to-day owing to its unthrifty condition. The autopsy revealed a small number of firm yellowish masses from ⅛ to ¼ inch diameter, with cheesy contents, in the liver. There are a considerable number of entozoa in this animal, in the small intestine worm tubercles, in the œsophagus a filaria. In the fourth stomach the mucosa is dark pink in color and beset with numerous

slight elevations having a central fine hole. These were subsequently found to be due to parasites (*Strongylus Ostertagi*), which are encysted under the mucosa for a time.

No. 64 (*native.*)—White steer, aged 2½ years, received from Maryland September 10, 1889. Exposed in field V (cattle ticks only) on September 14.

November 7.—Blood corpuscles, 2,780,000. Fully 20 per cent of the corpuscles contain the coccus-like peripheral body. During the first half of November this animal was dull, but continued to eat fairly well. No appreciable loss of flesh during this time. The disease would have passed unnoticed except for the examination of the blood.

July 4, 1890.—Reëxposed in field VI (North Carolina cattle with ticks).

August 19.—Temperature, 105.8; pulse, 66; respiration, 80. Blood corpuscles, 3,740,000. In two stained preparations, after a long search, one pair of intraglobular pyriform parasites detected. Urine normal. Feces soft.

August 20.—Temperature, 105.4; pulse, 64; respiration, 42. Corpuscles, 3,710,000. Fresh and stained preparations negative.

September 9.—Temperature, 102.7; pulse, 80; respiration, 96. Blood corpuscles, 3,154,000. In blood preparations no parasites seen. From 20 to 30 per cent of all corpuscles are enlarged.

September 16.—Temperature, 101. Blood corpuscles, 4,575,000. Enlarged corpuscles as before. A few ticks, one full grown, on animal.

September 29.—Temperature, 100.8. Blood corpuscles, 4,869,000. Macrocytes diminished in number. One red corpuscle detected containing a pair of pyriform parasites. Several corpuscles with peripheral coccus-like bodies.

October 7.—Temperature, 101.2; pulse, 39; respiration, 21. Corpuscles, 4,431,000. Blood examination negative.

October 14.—Temperature, 102; pulse, 96; respiration, 33. Corpuscles, 4,490,000. Blood examination negative.

November 1.—Temperature, 102.3; pulse, 54; respiration, 34. Corpuscles, 5,916,000. In fresh preparation nothing observed. In stained, one corpuscle with a pair of pyriform bodies.

November 3.—No marked loss of flesh from this exposure. (For temperature record, see pp. 273, 277, and 278.)

No. 65 (*native*).—Spotted heifer; age, 2½ years; received with No. 64 from Maryland, September 10, 1889.

September 14.—Exposed in field V (cattle ticks only).

November 4.—Animal apparently in good condition, but has been dull during the past ten days. Blood corpuscles have fallen to 1,720,000. There are present numerous corpuscles containing large stained granules, and an equal number of such as stain diffusely. A small number are infected with the small peripheral cocci.

December 2.—Blood contains to-day 3,463,000 corpuscles in a cubic millimeter. There has been no appreciable loss of flesh during this exposure. Disease only positively recognized by blood examination.

March 27, 1890.—Gave birth to a healthy calf at full term (No. 89).

September 20.—Along with calf reëxposed in field VI (North Carolina cattle with ticks).

September 30.—Temperature, 100.8; pulse, 72; respiration, 24. No ticks detected on animal. Blood corpuscles number 4,213,000. Nothing abnormal in fresh and stained preparations.

October 4.—Temperature, 100.4; pulse, 66; respiration, 66. Blood corpuscles, 3,896,000. No abnormal forms in stained preparations.

October 9.—Temperature, 101.4; pulse, 84; respiration, 54. Blood corpuscles, 3,738,000. In one fresh preparation of blood several large parasites seen in red corpuscles. Stained preparation negative.

October 18.—Temperature, 101.6; pulse, 60; respiration, 24. Blood corpuscles,

3,609,000. A considerable number of large corpuscles now present. No parasites detected.

November 2.—Lying down all day unable to rise and dies about 5 p. m. Had become greatly emaciated and weak during the first half of October and continued so during the second half without change. A chronic fœtid diarrhea accompanied the emaciation during October, and up to the time of death.

Autopsy at noon November 3: Body in poor condition. Weight about 650 pounds. Several adult ticks on escutcheon. Œdematous condition of the muscular tissue. In the abdominal cavity 3 to 4 liters of clear serum. Mesentery œdematous.

Heart: Ecchymoses very abundant over the apex and walls of the left ventricle. Few on the right. In both ventricles small, partly white, clots. Under the endocardium of the left, ecchymoses on the papillary muscles. Muscular tissue pale but normal; minute vessels injected.

Lungs normal with exception of slight emphysema of the cephalic lobes of right lung. Mucosa of trachea and bronchi coated with delicate white froth.

Spleen weighs but 1 pound. Not enlarged or congested. Several areas of extravasation under capsule.

Liver weighs about 7½ pounds. Not enlarged. Tissue quite flabby, probably due largely to post-mortem changes. Bile normal. Kidneys markedly pale. Post-mortem changes have begun. No lesions determinable. Urine quite yellow in color, barely alkaline; specific gravity, 1016. No albumen.

Œdematous condition of submucous tissue of fourth stomach. Slight arborescent injection of mucosa. In the small intestine a large number of worm nodules showing as bluish spots on the serous surface, and from ¼ to ½ inch in diameter. The remainder of digestive tract normal. Mucosa generally quite pale.

In blood from the subcutis, spleen, kidneys, and liver a considerable number of large (post-mortem) bacilli. No intraglobular parasites present. (For the temperature record, see pp. 273 and 280.)

No. 66 (*native*).—Spotted heifer, age 18 months, received September 10, 1889, from Maryland, and exposed in field IV (North Carolina cattle without ticks) September 14.

November 15.—Blood corpuscles about six millions.

November 27.—No result from this exposure.

July 4, 1890.—Reëxposed in field VI (North Carolina cattle with ticks).

August 22.—Temperature, 104.3; pulse, 80; respiration, 72. Corpuscles, 3,953,000. In fresh preparations a few corpuscles contain the bright bodies. In stained preparations 25 to 30 per cent contain the minute peripheral coccus-like bodies.

September 1.—Found dead, but still warm, early this morning. Except for the elevated temperature and slight dullness it had not appeared seriously ill up to this time.

Autopsy: Body in good condition, weighs about 500 pounds. A considerable number of ticks from the mature size down. Considerable subcutaneous fat.

Heart with some ecchymoses on ventricles along interventricular grooves and base. Both sides distended with large, rather soft dark clots. Heart muscle rather pale; cloudy and finely granular condition of the fibers. Heart's blood contains from 10 to 20 per cent of corpuscles infected with parasites.

Œdema of the lungs with two dark red hepatized masses, one in the left principal lobe, the other in one of the smaller lobes of the same lung.

Spleen weighs 4½ pounds; considerably engorged, but the pulp still quite firm and the Malpighian bodies partly visible. In cover-glass preparations of fresh pulp perhaps one-third of all the corpuscles contain large, round parasites. When stained it appeared that not less than 50 per cent of all the red corpuscles were infected with parasites about 2 μ in diameter. Many of the corpuscles contained double parasites; not infrequently four were present.

Liver weighs 10 pounds, enlarged. The parenchyma on section is yellowish brown. Minute bile ducts are visible to the naked eye as branched yellow lines. In sections

of fresh tissue there is seen an almost universal plugging of the ultimate bile canaliculi with solid bile associated with fatty degeneration. Rarely places are found with very little of such injection in which the fatty degeneration is most advanced. Numerous infected corpuscles observed in fresh preparations. In stained preparations fully one-half the red corpuscles are shown to be infected as in the spleen.

The gall bladder contains about 400 grams (1 pint) of very thick bile. Sp. gr., 1022. When allowed to stand, the lower half of the liquid represents a dense stratum of flakes and granules.

No extravasation or œdema about kidneys. Cortical portion sprinkled with petechiæ as large as pin heads. The color in general somewhat brownish. In fresh sections nothing abnormal. In stained preparations 10 to 20 per cent of the corpuscles infected. The bladder contains about 1 liter (1 quart) of urine of a dark, port-wine color, barely translucent in a test tube ⅝ inch in diameter.

The contents of third stomach dryer and firmer than usual. Both second and third contain much gravel. In the fourth stomach also considerable sand and gravel. Mucosa normal. Mucosa and contents of duodenum bile-stained. In the lower ileum mucosa pinkish. Contents of large intestine dry and coated with mucus. (For temperature record, see pp. 273 and 277.)

No. 67 (*Southern*).—Cow, 4 years old, received September 15, 1889, from near New Berne, N. C., and placed in field II.

April 29, 1890, gives birth to a calf, No. 86.

July 4.—Exposed in field VI (North Carolina cattle with ticks).

November 3.—No result. (For temperature record, see pp. 277 and 278.)

No. 69 (*native*).—Heifer, 2½ years old, received from Maryland, September, 1889, used during fall and winter in another experiment with No. 74 (exposure to skin disease of No. 73, which see) and not exposed to Texas fever until

July 4, 1890.—On this day, with her calf (No. 100), 8 weeks old, exposed in field VI (North Carolina cattle with ticks).

July 25.—Temperature 101.8. Corpuscles 5,341.000. Blood examination negative.

July 29.—Corpuscles 5,536,000. Blood examination negative.

August 4.—Corpuscles 6,050,000. Blood examination negative.

August 11.—Corpuscles 4,698,000. A few corpuscles containing intraglobular coccus-like bodies.

August 13.—Corpuscles 6,090,000. Condition of blood the same as at preceding examination.

August 15.—Temperature, 100.9; pulse, 66; respiration, 30. Corpuscles, 4,640,000. About 10 per cent contain the peripheral cocci.

August 23.—Temperature, 105.8; pulse, 76; respiration, 28. Corpuscles, 2,855,000. In stained preparation very few coccus-like bodies detected.

September 3.—Dies at 7 a. m. Examined several hours later. Body generally emaciated. Weighs about 400 pounds. Many ticks of all stages on body.

Heart muscle pale, with some ecchymoses beneath epicardium. Parenchyma in condition of fatty degeneration. Blood taken from the heart which appears quite thin and watery, was examined fresh in the warm chamber between 35° and 43° C. Many of the corpuscles are quite large, some containing minute vacuoles in groups. A considerable number of hæmatoblasts are present, some with protruding nucleus. The blood probably did not contain more than a million red corpuscles in a cubic millimeter at the time of death. A considerable number are invaded by large parasites; some contain two or three individuals. Some of the parasites have already assumed the spherical form. A few still show distinct and rapid changes of form in the warm chamber five hours after death (Plate VIII, Fig. 1). In many corpuscles the bright bodies present. In stained preparations some diffusely stained corpuscles are seen. (These are present in spleen and liver also.)

Lungs, normal.

Spleen weighs $2\frac{3}{8}$ pounds. Only moderately engorged. Trabeculæ and Malpighian bodies visible on section. Moderate number of red corpuscles within large cells and considerable free pigment in irregular masses. In stained preparations 10 to 20 per cent of the corpuscles are seen infected with from one to four parasites.

Liver weighs about 8 pounds. Somewhat enlarged. At the hilus some œdema of the connective tissue. Parenchyma yellowish brown. The intralobular veins appear distinctly to naked eye as patent vessels surrounded by a yellowish zone. In the peripheral portion of the acinus the bile injection is complete. Numerous intraglobular parasites detected in fresh preparations. In stained cover-glass preparations a rough estimate makes the infection as extensive as in the spleen.

In sections of liver tissue (hardened in alcohol imbedded in chloroform paraffin and) stained in hæmatoxylin and eosin or in alum carmine, the protoplasm of the cells is in a peculiar reticulated or vacuolated condition. In some places, the vacuoles are as large as or even larger than the nuclei and from one to three in a cell (fatty degeneration). Nuclei show signs of degeneration and there are some missing, but there are no compact necrotic areas in the sections examined. Bile injection and red corpuscles containing parasites not traceable. Bile in the gall bladder extremely loaded with suspended flakes; semiliquid.

Kidneys have a uniformly dark-brownish appearance on section. No perinephritic œdema or extravasation. In fresh sections the epithelium of the convoluted tubes of the cortex contains much pigment. In the capillaries some of the corpuscles show the pale intraglobular bodies quite distinctly in such sections. In stained preparations the corpuscles are infected as in spleen and liver. There are also a very large number of stained bodies about the size of the parasites free. In the bladder are 2 to 3 quarts of urine having a deep port-wine color. In layers $\frac{3}{4}$ inch deep it is translucent. Abundant precipitate is formed when acetic acid is added and it is boiled.

In fourth stomach a considerable quantity of sand and gravel. In the lamellar portion some erosions of irregular shape with hemorrhagic base. Mucosa otherwise normal. In the lower small intestine numerous worm tubercles. In the large intestine very dry balls of feces coated with mucus. (For temperature record, see p. 277.)

No. 70 (native).—Yellow steer, $2\frac{1}{2}$ years old. Received September 30, 1889, from Maryland, and exposed in field I (North Carolina cattle with ticks). Died about noon October 19.

Autopsy: Steer in fairly good condition. A very few small ticks on the body.

The surface of the heart, especially on the left ventricle and interventricular grooves, sprinkled with small ecchymoses.

Lungs normal.

Spleen 17 inches long, $5\frac{1}{2}$ inches across the widest portion. Pulp soft, dark, concealing the Malpighian bodies and trabeculae completely. In stained preparations many infected corpuscles (Plate IV, Fig. 2).

Liver enlarged, firm, edges rounded. The surface has a mottled yellowish appearance. On section small areas of a yellowish color throughout. Blood flows freely from the cut surface. The biliary injection was not observed in a few preparations of fresh tissue. The hepatic cells contain large and small fat globules. Blood from the liver, when stained, shows a large number of red corpuscles invaded each by a pair of parasites elongated in form, usually close together.

Bile of a dark-green color and containing as yet only a slight amount of solids.

Under the fat enveloping the kidneys, there is considerable œdema of a sanguinolent character. The parenchyma of the kidneys uniformly of a dark brownish-red color. In the blood from the kidneys the intraglobular bodies are as numerous as in the blood from the liver.

Gastrointestinal tract appears normal with exception of caecum and upper colon, the mucosa of which contains bluish spots $\frac{1}{2}$ inch across, the result of blood extravasation.

Cultures were made from the various organs, but in place of taking large quantities of blood or tissues for inoculation only loops of blood were used, and in inoculating from the tissues a straight platinum needle was used to pierce the organ and the quantity thus adhering used to inoculate the culture media. In this way cultures were prepared from the blood (heart), spleen, liver, and kidneys, three or four tubes being inoculated from each organ. The media used were simple agar, agar with glycerin, neutralized and slightly acid, and blood serum. Of the 14 tubes thus prepared, only one showed signs of growth after ten days. This contained one colony made up of micrococci. (For the temperature record, see p. 271.)

No. 71 (*native*).—Heifer, 3½ years old; received September 10, 1889, from Prince George County, Md.

October 19.—Exposed in field I (North Carolina cattle with ticks).

December 5.—No result from exposure. Blood was not examined at any time.

August 13, 1890.—Reëxposed in field VI (North Carolina cattle with ticks).

September 4.—Temperature, 105.3; pulse, 108; respiration, 60; corpuscles, 1,655,000. One infected corpuscle detected. Enlarged forms with feebly tinted disc and several hæmatoblasts.

September 6.—Animal found dead this morning. Had been very weak for several days. Yesterday she was taken with convulsions, falling down several times within fifteen minutes. She appeared blind and ran against various obstacles.

Autopsy: Considerable loss of flesh. Weight about 600 pounds. On the skin numerous small and a few large ticks.

Lungs emphysematous and œdematous. Very extensive ecchymoses of the ventricular surface of the heart under epicardium. Both sides distended with large, dark, soft clots. In the blood very few parasites. Corpuscles shriveled. Hæmatoblasts in small numbers. Capillaries and larger vessels of myocardium filled with red corpuscles. No fatty degeneration.

Spleen weighs 3¾ pounds. The pulp is of a uniform dark brownish red appearance, quite soft and wells out from the incision. Very few corpuscles with parasites. Some hæmatoblasts and feebly stained corpuscles.

Liver weighs 14 pounds, much enlarged. Parenchyma yellowish brown. Bile-injection and fatty degeneration as in No. 69. Much blood flows from the larger hepatic vessels when the organ is cut into. Groups of very minute ruby-red needle-like crystals scattered over fresh sections. In stained preparations very few corpuscles containing parasites. A small number of faintly stained macrocytes. Gall-bladder contains about one-half pint of bile, so thick that it scarcely flows, having become nearly solid with suspended flakes and particles. Kidneys with cortical portion very pale. In fresh sections nothing abnormal observed. Blood corpuscles and parasites as in liver. Bladder contains about 2 quarts of urine free from hæmoglobin, pale yellow. Specific gravity, 1014, neutral. A slight flocculent precipitate of albumen obtained. In marrow of ribs many diffusely stained macrocytes but no infected corpuscles.

In digestive tract the fourth stomach shows on the mucosa of lamellar portion a very large number of dark-red dots from ½ to 1^{mm} in diameter and about 3^{mm} apart. The center of these dots is paler than periphery. The same appearance in upper duodenum which, in addition, is much pigmented. In ileum a considerable number of worm tubercles of which a few are found scattered through the large intestine. Pigmented condition of the summit of the mucous folds in cæcum and upper colon. In rectum small dry fecal balls covered with mucus. (For the temperature record, see pp. 271, 279, and 280.)

No. 73 (*native*).—Cow, 6 years old, received November 13, 1889, from Clark County, Va., affected with necrotic skin disease prevalent during that season.

May 23, 1890.—Several of the larger patches, from which the skin had sloughed away, still unhealed and covered with scabs.

July 4.—Exposed in field IX (North Carolina soil).

September 2.—Temperature, 101.2; pulse, 58; respiration, 24. Corpuscles, 7,516,000. In fresh preparations corpuscles are normal. A few contain the minute bright bodies. In stained preparation no intraglobular bodies detected.

September 18.—Temperature, 101. Corpuscles, 6,389,000.

October 8.—Temperature, 101. Corpuscles, 5,327,000. In fresh preparations corpuscles are normal. A few contain the motile bright bodies. Some of these have a short, rodlike form. In some corpuscles a larger, paler, round body, about 0.7 μ in diameter, also changing place within the corpuscle. In stained preparations no intraglobular bodies seen.

November 3.—Exposure without result. (For the temperature record, see p. 281.)

No. 74 (*native*).—Heifer, 15 months old, received September, 1889, from Maryland. (For its use until exposure to Texas fever, see No. 69.)

May 26, 1890.—Placed (with No. 91) in field I to determine whether the infectious agent of Texas fever had survived the winter.

September 25.—No result from this exposure. Transferred to field II (Texas cattle with ticks).

September 30.—Temperature, 101.4; pulse, 66; respiration, 30. Corpuscles, 6,662,000. In fresh preparations, blood-corpuscles normal in appearance. A very large number contain each a very minute bright body. One of these observed more closely, appears as a short rod, and has a restricted movement within the globule. It goes toward the center and back, occasionally disappearing from view.

In stained preparations nearly every corpuscle contains a very minute, not well outlined, stained body usually half way between center and border of the globule. In some, two are seen near each other (Plate IV, Fig. 1).

October 8.—Temperature, 102.2; pulse, 72; respiration, 30. Corpuscles, 5,783,000. In fresh preparations only a small number of corpuscles containing bright bodies. In stained preparations the infection appears as extensive as at preceding examination.

October 12.—Quite weak and losing flesh.

October 15.—Temperature, 106.5; pulse, 120; respiration, 48. Corpuscles, 2,185,000. Blood corpuscles in fresh preparations largely crenated and shriveled. Several bright bodies within corpuscles; one in motion. Also several pyriform intraglobular bodies. In stained preparation a few of the latter forms detected, also a small number of red corpuscles sprinkled over with very minute stained particles.

October 16.—Cow found dead early this morning.

Autopsy: Condition of body still fair, although there has been considerable emaciation since the exposure. Weight, 450 pounds. Three ticks in last moult found on the body.

Thoracic organs. Faint ecchymosis on the left ventricle of heart. Considerable extravasation under endocardium of the same ventricle, especially on papillary muscles. Contents of right ventricle still fluid; left, empty. Capillary injection of the myocardium and finely granular condition of the fibers.

The blood coagulates slowly and imperfectly when placed in beakers. After several hours it has assumed a soft, gelatinous condition and may be poured from beaker in lumps mingled with thick liquid blood. In fresh preparations of blood at 10:30 a. m., both from heart and jugular, a moderate number of corpuscles contain round parasites either single or in pairs, 1.5 μ in diameter, and very few of the bright bodies. In stained preparations the parasites appear both as round and pyriform bodies.

Lungs imperfectly collapsed. In the trachea and bronchi much cream-colored froth. In the right ventral lobe, dorsal portion, a dark-red hepatized mass under pleura about 1 inch in diameter.

Abdomen: The omentum covered with hyperæmic spots, consisting of delicate vascular fringes. When they are placed under the microscope the capillaries are seen filled with red globules, some of which show the pale parasites within.

Spleen weighs 4¼ pounds; very large and soft to the touch. The distended capsule retracts from the incision. Parenchyma has a dark, glistening appearance, resembling blackberry jam and is partly disintegrated. In teased preparations much phagocytosis (involving red corpuscles) and very little free or intra-cellular pigment. About 10 per cent of the corpuscles contain parasites 1 μ in diameter, fully one-half of which are double forms.

Liver weighs 10¾ pounds. Considerably enlarged. Color yellowish brown with paler mottling over the surface more especially in the middle portion. The parenchyma on section shows the same yellowish color. From the hepatic vessels blood flows abundantly. The smallest bile ducts visible to the naked eye distended with bile. Thin sections have a decided yellowish color. The bile injection appears in spots under the microscope and the smallest interlobular bile ducts are filled with yellow bile. Fatty degeneration slight. In preparations not less than 30 per cent of the blood corpuscles are invaded by pairs of parasites.

Portions of the liver were hardened in alcohol, imbedded in chloroform paraffine and the sections stained in hæmatoxylin and eosin. In such sections under a low power only a narrow peripheral zone remains in which the acini appear normal. There is even here an exaggerated size of the capillary network. Under a high power the difference between the central and peripheral regions is observed to be due to a partial disintegration of the cell nuclei. These instead of staining almost uniformly consist of a pale round body containing a variable number of larger granules, or the nuclei may be represented merely by a group of such deeply stained granules. The protoplasm of cells with such nuclei is not distinctly outlined. The capillaries of the acini are well filled with red corpuscles and in many of them every corpuscle contains one or two parasites. These appear at 500 diameters as minute as cocci stained blue. In some capillaries no infection is noticeable and in general the infection includes every corpuscle when present at all.

The gall bladder contains about 8 ounces of bile so thickly impregnated with flakes and mucus that it scarcely flows. The flakes of yellow pigment are up to 2^{mm} in diameter.

Around and in the fat of both kidneys considerable œdema associated with the blood extravasation. The parenchyma of both has a uniform dark brownish-red appearance, even to tips of papillæ. In fresh sections the entire capillary system is found gorged with red blood corpuscles. In some the latter have broken down into granular masses. Pigment granules diffused through the parenchyma more or less densely everywhere. In stained cover-glass preparations nearly every corpuscle is found infected. There are in addition large numbers free (Plate VI, Fig. 3). In sections of the kidney (hardened in alcohol) stained in Ehrlich's hæmatoxylin no structural changes of the parenchyma were recognized. The capillaries are distended with red corpuscles within which the parasites are readily distinguished.

The bladder contains about 3 quarts of urine which has an opaque, dark red appearance. It is barely translucent in layers, ¾ inch deep. Reaction slightly alkaline. Sp. gr. 1012. An abundant flocculent brownish precipitate with acetic acid. According to Esbach 1.2 per cent albumen.

Digestive tract. Fourth stomach contains some turbid liquid. Mucosa uniformly bright pink in color. In pyloric portion a few erosions with blackish base. Mucosa of duodenum covered with a layer of bile-stained mucus; pinkish in color. Mucosa of ileum similarly injected.

Cæcum and upper colon distended with firm masses of feces. Pigmentation and injection appear in occasional patches. Worm nodules 2 to 3^{mm} in diameter. A few specimens of *Œsophagostoma* and numerous specimens of *Dochmius* imbedded in a soft coagulum mixed with mucus. In lower colon and rectum many fine fecal balls. Mucosa slightly injected in patches. (For the temperature, see pp. 274, 275.)

No. 75 (*native*).—Calf, age 4 months, born on the Station, of cow No. 8. Exposed in field I (Southern cattle with ticks), June 27, 1889. Very sick from August 22 to

September 10. At the latter date it was very weak and thin and its abdomen enlarged (pot-bellied). It remained in this condition up to October, at which time it began to improve. In December it was still thin and stunted. It did not recover until the following spring.

December 2, 1889.—Corpuscles 5,620,000. Stained preparations show nothing abnormal.

July 4, 1890.—Placed in field VI (Southern cattle with ticks). Up to November 1 there were no noticeable symptoms of Texas fever. For the temperature record, see pp. 270, 271, 277, and 278.

No. 76 (*native*).—Heifer 1 year old, when received May 20, 1890, from the District of Columbia.

July 4.—It was exposed in field VIII (cattle ticks only).

August 14.—Temperature, 104.1. Blood corpuscles, 4,966,000. In fresh preparations nothing abnormal detected. Stained preparations equally negative.

August 16–18.—Heifer growing thin and weak quite rapidly.

August 18.—7 a. m. Animal walking about, but very weak and unsteady in its movements. At 9 a. m. lying down, unable to rise. Temperature, 99.7; pulse, 124; respiration, 16. The skin almost bloodless. Blood obtained with difficulty from skin incisions. Corpuscles, 3,475,000. In fresh preparations a few double pyriform intraglobular parasites observed. The same detected in stained preparations. As the temperature of the animal was falling rapidly and the animal now unable to rise and evidently dying, it was killed at 11 a. m., by a blow on the head.

Autopsy: On the skin of thighs, escutcheon, and belly a large number of ticks just completing the last moult. Lungs normal. Some adult specimens of *Strongylus micrurus* (both sexes) in terminal bronchi. Heart fibers have undergone cloudy swelling. In blood from the right ventricle scarcely any parasites present. Spleen weighs 1¾ pounds. Enlarged; capsule tense, under it a few hemorrhagic patches. On section, pulp dark, still consistent, however. In teased preparations some large cells containing from one to four red corpuscles. No free pigment. In stained preparations not more than 1 per cent of the red corpuscles contain the parasite.

Liver weighs 5½ pounds. Evidently enlarged. Yellowish brown. In fresh sections small areas of the lobules show bile injection, while the fatty degeneration is more or less uniform over the lobule. Occasional interlobular bile ducts appear as yellow streaks. In teased preparations made some hours after death fully 10 per cent of the corpuscles contain apparently round or oval pale bodies from 1.5 to 2 μ in diameter. These are usually in pairs situated a variable distance apart. In some only one, in others four bodies are seen. In stained preparations made at autopsy the parasites are all pyriform in shape.

About 8 ounces of bile in gall bladder. Specific gravity, 1022. Holds in suspension a small amount of flaky yellow material.

Kidneys are of a uniformly dark-brownish red color throughout. Fresh sections magnified appear dusted over with minute reddish pigment granules. The capillaries everywhere distended with blood corpuscles. In those of the medulla it is easy to see with high powers in fresh sections each corpuscle containing one to four parasites. When cover-glass preparations are stained few corpuscles are present, but everyone contains a pair of parasites. Besides these there are numerous free bodies identical with those in the corpuscles.

In the bladder about 3 pints of urine containing a large amount of hæmoglobin so that it is barely translucent in layers an inch deep. Specific gravity, 1017. Slightly acid. On boiling, a brownish flocculent precipitate is formed. In the slight, amorphous deposit a few short granular casts.

Digestive tract: In fourth stomach the mucosa of laminæ pinkish and beset with small elevations having a central hole (worm pits). Numerous specimens of *Strongylus contortus* actively moving. In duodenum specimens of *Dochmius*. Mucosa bile-stained. Worm nodules in ileum. In the upper colon masses of clotted blood

in which are imbedded round worms (*Œsophagostoma*). The origin of the blood not traceable. (For the temperature record, see p. 281.)

No. 79 (*native*).—Born April 9, 1890, of cow No. 50.

July 4, 1890.—Exposed in field VI with No. 50 (North Carolina cattle with ticks).

October 9.—Temperature, 103.4; pulse, 96; respiration, 72 (probably elevated by excitement in being caught). Corpuscles, 6,767,800. In fresh and stained preparations corpuscles appear normal. About 1 per cent contain peripheral cocci. These are 0.5–0.6 in diameter.

October 25.—Temperature, 104; pulse, 72; respiration, 30. Corpuscles, 5,707,000. In fresh preparation several corpuscles containing each a bright motile body. In stained preparations from 1 to 2 per cent of peripheral cocci.

No noticeable symptoms of Texas fever excepting the slightly elevated temperature (for record see pp. 279, 280) and the blood parasites as observed above.

No. 80 (*native*).—Cow, age 7 years when received May 26, 1890, from St. Mary County, Maryland. Several adult specimens of a species of tick (*Amblyomma unipunctata*), differing from the cattle tick proper, found on this animal when received.

July 5, 1890.—Exposed in field II (Texas cattle with ticks). (See No. 82.)

July 31.—Corpuscles, 6,290,000. In fresh and stained preparations nothing abnormal.

August 4.—Corpuscles, 5,052,000. In fresh and stained preparations nothing abnormal.

August 7.—Corpuscles, 5,631,000. In fresh and stained preparations nothing abnormal.

Animal is losing flesh slowly.

August 23.—Temperature, 101.6; pulse, 42; respiration, 15. Corpuscles, 5,422,000. Both fresh and stained preparations negative.

August 25.—Temperature, 106.2; pulse, 56; respiration, 27. Corpuscles, 5,434,000. In fresh preparations a moderate number of corpuscles contain bright motile points. In stained preparations no parasites were detected.

August 28.—1 p. m. Temperature, 101.8; pulse, 100; respiration, 48. Corpuscles, 2,025,000. Perhaps 2 per cent contain small round parasites 0.8-1 μ in diameter near the center of the corpuscle. Emaciation very marked. Animal very weak and sways with its hind quarters when it attempts to stand or walk. This morning urine contained much hæmoglobin. The feces are thin and streaked with blood. As the cow would presumably not survive the night, she was killed by a blow on the head.

Autopsy: A few small ticks on inside of thighs and around udder.

Thoracic cavity. Lungs normal with exception of several small areas of collapse in both principal lobes. Ecchymoses on both auricles and along interventricular groove of heart. Infection of one to two per cent of corpuscles in blood from the right ventricle. Some of the intraglobular bodies pyriform, others roundish; most in pairs.

Abdomen: Spleen weighs 3 pounds. Moderately firm to the touch. Capsule retracts when incised, displaying an engorged, uniformly, dark-red pulp. In teased pulp much pigment in lumps, either free or intracellular. About 10 per cent of the corpuscles contain one or two parasites each. When in pairs the parasites usually elongated, pyriform.

Liver weighs 12¾ pounds. Considerably enlarged and congested. In fresh sections slight fat infiltration observed. Nuclei of hepatic cells distinct. The latter are in some places surrounded by a network of injected bile capillaries. There are also some spherical reddish masses of a peculiar luster, slightly larger than red corpuscles, scattered over the section. Parasites easily detected within the corpuscles. In stained preparations from 20 to 30 per cent of all corpuscles contain each one or two parasites, usually pyriform.

In the gall bladder nearly a pint of bile of a deep greenish color and containing much flocculent matter in suspension. When allowed to subside only the upper fifth of the layer free from solids. The remainder scarcely flows from the bottle.

Slight sanguinolent œdema around pelves of both kidneys. Parenchyma more or less congested and considerable extravasation in pelvis. In fresh sections, including base of pyramids, the blood vessels found distended with blood corpuscles, in almost everyone of which a pair of pale parasites could be readily distinguished. The tissue sprinkled over with very minute pigment particles. In stained preparations the infection of corpuscles almost as extensive as in liver. There are also numerous free parasites. Bladder contains nearly 3 pints of urine, which has a deep port-wine color in layers three-quarters inch deep (Plate III, Fig. 4). Faintly alkaline. Specific gravity, 1016. Abundant precipitate when simply acidified with acetic acid. In the amorphous deposit formed after some time a few straight granular casts.

In the marrow of ribs very few hæmatoblasts. One capillary observed which had been preserved entire in a cover-glass preparation. This was packed with corpuscles, in many of which parasites are present.

Digestive tract. Mucosa of fourth stomach of a uniformly bluish-red color. In duodenum much bile. Mucosa with minute vessels injected. Mucosa of the entire small intestine hyperæmic; in ileum punctiform hemorrhages. Similar petechiæ and small hemorrhagic patches in large intestine. (For the temperature record, see pp. 274 and 276.)

No. 82 (*native*).—One week old when received, June 5, 1890, and placed with and adopted by cow No. 80, which was still giving milk.

July 5.—Placed with No. 80 in field II (Texas cattle with ticks).

August 20–September 11.—Has shown slight symptoms of Texas fever, as indicated by elevated temperature and emaciation.

September 11.—Temperature, 101.4; pulse, 72; respiration, 48. Corpuscles, 5,630,700. In fresh preparations corpuscles crenated and examination imperfect. In stained preparations nothing abnormal. A small number of ticks of various sizes on animal.

October 11.—Temperature, 102.5; pulse, 84; respiration, 33. Corpuscles, 3,542,800. In fresh preparations nothing abnormal. In stained preparations a few corpuscles containing peripheral cocci observed. A few ticks observed.

November 13.—Temperature, 100.5; pulse, 75; respiration, 18. Corpuscles, 4,240,000. In preparations of blood, enlarged corpuscles but no parasites observed. Animal very weak and emaciated and covered with lice brought by Texas cattle. Blood obtained from skin with difficulty.

December 2.—Temperature, 100.4; pulse, 104; respiration, 26. Corpuscles, 5,643,000. Examination of fresh and stained preparations negative. Animal very weak and scarcely able to stand. A liquid fœtid diarrhea for several days past.

December 6.—Animal has been unable to get up since December 4. Diarrhea persists.

Killed by a blow on the head. General condition very poor, weighs 93 pounds. Heart and lungs normal with the exception of a few lung worms in one bronchus. Spleen weighs 3⅝ ounces, liver 1⅞ pounds. Both normal in appearance. Gall-bladder contains viscid bile with more or less flocculent matter in suspension. Kidneys congested. Urine in bladder free from hæmoglobin. Œdematous condition of coats of fourth stomach and slight hyperæmia of mucosa of small intestine. The organs were not examined microscopically. (For the temperature record, see pp. 274, 276.)

No. 83 (*native*).—Calf of cow No. 48; 8 weeks old when exposed, September 14, 1889, in field V (ticks only). (For the temperature during this period, see p. 273.)

The blood was not examined. External evidences of disease not observed.

No. 85 (*native*).—Calf, 4 weeks old, May 7, 1890. At this date placed on and adopted by cow No. 49.

July 4.—Exposed in field VI (North Carolina cattle with ticks).

August 21.—Removed with No. 49 to field IV (field for exposure of healthy to sick natives). Temperature elevated from August 23 to September 1 indicating the presence of Texas fever.

September 4.—Temperature, 103.1; pulse, 72; respiration, 72. Corpuscles, 5,040,000. In stained preparations a considerable number of large red corpuscles (macrocytes).

September 24.—Temperature, 102.7; pulse, 87; respiration, 48. Corpuscles, 6,113,000. In fresh preparations nothing abnormal. A very few peripheral cocci in stained preparation.

October 6.—Temperature, 102.4; pulse, 84; respiration, 27. Corpuscles, 5,138,000. Fully 10 per cent of corpuscles infected with peripheral cocci.

November 11.—Temperature, 102.2; pulse, 78; respiration, 45. Corpuscles, 5,843,000. About 1 to 2 per cent of infected corpuscles still in the circulation. Animal in fairly good condition. (For the temperature record, see pp. 279 and 280.)

No. 86.—April 29, 1890. Born of cow No. 67 (North Carolina cow brought from the South last summer).

July 4.—Exposed to North Carolina cattle with ticks in field VI.

October 9.—Temperature, 103.2; pulse, 180; respiration, 120. (Caught after much chasing.) Corpuscles, 5,240,000. Four bright bodies within corpuscles detected in fresh preparation; two are rod-like. In stained preparation 2 to 3 per cent of corpuscles containing peripheral cocci. One nearly adult tick on animal.

October 22.—Temperature, 104.3; pulse, 108; respiration, 30. (Rapidity of pulse probably due to chasing.) Corpuscles, 4,308.000. They vary more or less in size. In a fresh preparation one minute, pale, peripheral body seen. In stained preparations about 5 per cent of the corpuscles infected with peripheral cocci.

October 30.—Temperature, 103.5; pulse, 96; respiration, 30. Corpuscles, 3,579,000. Fresh preparations negative. In stained preparations about 5 per cent of infected corpuscles.

November 4.—Temperature, 103; pulse, 84; respiration, 24. Corpuscles, 4,312,500. Some enlarged. In several, bright motile bodies and pale peripheral bodies. In stained preparations still 2 to 3 per cent of infected corpuscles. (For the temperature record, see pp. 279 and 280.)

No. 87—March 21, 1890. Born of cow No. 59 (North Carolina cow, brought from North Carolina last summer).

July 4.—Exposed in field VI (North Carolina cattle with ticks).

August 21.—Temperature, 107. Corpuscles, 6,687,500. A few corpuscles contain exceedingly minute bright bodies. Stained preparations negative.

September 20.—Temperature, 102.1. Corpuscles, 5,896,000. Fresh preparations negative. In stained preparation not less than 5 per cent of corpuscles containing peripheral cocci about 0.6 μ in diameter. A small number of half-grown ticks on thighs.

October 7.—Animal excited in being caught. Temperature, 102.7; pulse, 96; respiration, 40. Corpuscles, 5,084,000. In fresh preparation numerous corpuscles containing bright bodies, chiefly near periphery of cell. In stained preparation about 1 to 2 per cent of infected corpuscles.

October 22.—Animal excited. Temperature, 104; pulse, 96; respiration, 42. Corpuscles, 6,270,000. Fresh preparations negative. In stained preparations 1 to 2 per cent of corpuscles containing peripheral cocci.

October 25.—Temperature, 104.1; pulse, 87; respiration, 27. Corpuscles, 5,596,774. One intraglobular motile bright body in one fresh preparation. In stained preparations 1 to 2 per cent peripheral cocci. (For the temperature, see pp. 279 and 280.)

No. 89 (*native*).—Born of cow No. 65, March 27, 1890.

September 20.—Placed with No. 65 in field VI (North Carolina cattle with ticks).

October 6.—Temperature, 104.5; pulse, 120; respiration, 60. Corpuscles, 3,936,500. In fresh preparation slight tendency of corpuscles to crenate. One corpuscle containing a large pyriform parasite detected. Stained preparations lost.

October 11.—Temperature, 103.8; pulse, 108; respiration, 54. Corpuscles, 3,027,000. No parasites detected in fresh and stained preparations. Corpuscles tend to crenate. Some macrocytes present. Several small ticks found.

October 25.—Temperature, 103.4; pulse, 96; respiration, 30. Corpuscles, 3,606,000. Both fresh and stained preparations negative.

October 30.—Temperature, 104.2; pulse, 78; respiration, 27. Corpuscles, 4,254,500.

Several very minute bright and pale bodies within corpuscles. Stained preparations negative.

November, 11.—Temperature, 103.6; pulse, 78; respiration, 42. Corpuscles, 3,218,800. Corpuscles somewhat enlarged. No parasites detected.

November 24.—Temperature, 103.8; pulse, 92; respiration, 52. Corpuscles, 3,300,000. In stained preparations 2 to 3 per cent of corpuscles contain peripheral cocci. Animal in fair condition. (For temperature record, see p. 280.)

No. 90 (*native*).—Young bull, one year old when received, May 26, 1890, from Prince George County, Md.

August 25.—Exposed in field VI to North Carolina cattle with ticks.

September 12.—A large number of small ticks on animal. Temperature, 103.4; pulse, 96; respiration, 36. Blood-corpuscles, 1,974,000. Several bright bodies but no parasites detected in corpuscles. In stained preparations corpuscles more or less crenated. About 10 per cent contain each from 5 to 10 unusually large granules. There are in addition some diffusely stained corpuscles and some with many very fine stained particles.

Sept. 16, 11 a. m.—Animal lying down unable to rise. Temperature, 100.8. Blood exceedingly thin; only 1,000,000 red corpuscles. From 20 to 30 per cent contain large parasites in pairs, the majority pyriform and provided each with a dark round body barely visible at 500 diameters (Plate VIII, Fig 5).

1.30 p. m.—In same preparation most of the pyriform bodies have assumed the round form. Animal killed by a blow on the head. Temperature at this time 101.4. Heart's blood examined at 2 p. m. and 3.15 p. m. The same appearances as in blood from the skin. Hæmatoblasts present. A few bright motile bodies within corpuscles detected. At 3.15 p. m. many of the parasites had become spherical.

Autopsy immediately after death.—Weight of animal about 450 lbs. Many ticks on thighs and abdomen. Nothing abnormal in thoracic cavity excepting slight clouding of heart fibers when examined microscopically. Spleen weighs 2⅝ pounds. Slightly engorged and quite firm. In both fresh and stained coverglass preparations about one-third of all corpuscles contain round parasites about 2 μ in diameter. Fully one-half are double. Liver weighs about 7¼ pounds. Parenchyma yellowish brown. In fresh sections the bile injection is observed in spots within the lobules. Fatty degeneration marked throughout. In fresh and stained preparations the same infection of red corpuscles as in spleen. Many bodies are pyriform. Gall bladder contains a little bile holding much solid matter in suspension.

Kidneys are somewhat paler than normal. In fresh sections little blood in capillaries. The convoluted tubules are plainly marked as yellowish brown bands owing to the pigment contained in the epithelium. Considerable pigment generally diffused in very minute particles. The infection of corpuscles as in liver. Urine contains considerable hæmoglobin. Specific gravity, 1013. Neutral. Digestive tract with its mucosa rather pale. Marrow of ribs shows nearly the same infection of corpuscles as that observed in liver, spleen, kidneys, and blood preparations. (For temperature record, see pp. 279 and 280.)

No. 91 (*native*).—Heifer, 3 years old, received May 26, 1890, from Prince George County, Md. Placed in field I on this day to test survival of infection of 1889. (See also No. 74.)

September 16.—Temperature, 101.8. Corpuscles, 5,540,000. No abnormal condition of the blood detected in fresh and stained preparation.

October 1.—There being only a negative result from this exposure, the animal was transferred to field VI (North Carolina cattle with ticks). Temperature, 101.8; pulse, 60; respiration, 22. Corpuscles, 4,672,000. One corpuscle containing a bright motile body detected. Examination of stained preparations negative.

October 7.—Temperature, 101; pulse, 96; respiration, 18. Corpuscles, 4,833,000. Blood examination as before.

October 14.—Temperature, 101.8; pulse, 66; respiration, 30. Corpuscles, 4,837,500. Blood examination as before.

October 30.—Corpuscles, 4,670,000. Examination of blood negative. (For temperature record, see pp. 274, 275, and 280.)

No. 93 (*native*).—May 23, 1890. Born to-day of cow No. 95.

July 4.—Placed with No. 95 in field VI (North Carolina cattle with ticks).

August 16.—Temperature, 104.4. Corpuscles, 4,775,000. They tend to become crenated. In stained preparations not less than 20 per cent contain each one or more peripheral cocci.

August 19.—Temperature, 103.8; pulse, 96; respiration, 40. Corpuscles, 3,460,000. In stained preparation many corpuscles are enlarged. Not less than 10 per cent contain peripheral cocci.

August 23.—Temperature, 102.6; pulse, 88; respiration, 18. Corpuscles, 3,160,000. Enlarged corpuscles as before; a few are punctated. In stained preparations from 1 to 2 per cent of corpuscles infected with peripheral bodies.

September 22.—Temperature, 103.7; pulse, 96; respiration, 80. Corpuscles, 3,940,000. Enlarged corpuscles very few. Only an occasional infected corpuscle detected.

This calf has been sick and in very poor condition since August 16. The cornea of left eye is ulcerated. Similarly the left ear in which the metal tag was inserted.

A considerable number of ticks of various stages, including such as are fully matured on the animal.

Killed by a blow on the head.

Autopsy.—Weight, 150 pounds; heart and lungs normal; spleen, of normal consistency, weighs ¾ pound; liver weighs about 2 pounds, normal in appearance; cells contain exceedingly minute pigment granules; bile holds in suspension a small number of large flakes; kidneys rather pale, otherwise normal; small amount of pigment in cells; urine pale yellow, alkaline. Specific gravity, 1037. No albumen.

Digestive tract not markedly affected. In the fourth stomach minute worm-pits (*Strongylus Ostertagi*). *Strongylus contortus* present in large numbers. In ileum many worm-nodules under mucosa.

In stained preparations of spleen, liver, and kidneys, no parasites detected. In heart's blood there were the same number of corpuscles infected as in blood from the skin.

Marrow of rib contains hæmatoblasts with 2 to 4 nuclei each. (For temperature record, see pp. 279 and 280.)

No. 95 (native).

[Cow, 3½ years old. Received Nov. 13, 1889, from Clarke County, Va.; affected with a skin disease at this time (see No. 73). Gives birth to calf No. 93, May 23, 1890. July 4, 1890, exposed in field VI (North Carolina cattle ticks).]

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulses.	Respiration.	Remarks. (For temperature record see p. 279.)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
Aug. 7, 1890	5, 938, 500	Negative	5 per cent peripheral cocci.	Normal	Normal	102. 6	....	....	
Aug. 13, 1890	4, 150, 000	......do	20 per cent peripheral cocci.	....do	....do	......	....	....	
Aug. 14, 1890	3, 709, 000	......do	......do	....do	....do	102. 8	90	42	
Aug. 15, 1890	4, 040, 000	......do	15 per cent peripheral cocci.	....do	....do	101. 7	90	36	
Aug. 16, 1890	3, 436, 000	......do	10 per cent peripheral cocci.	....do	A few punctated corpuscles.	101. 0	78	25	
Aug. 17, 1890	....	....	......do	Macrocytes present.	Some punctated corpuscles.	101. 0	78	34	
Aug. 18, 1890	3, 300, 000	Negative	......do	....do	....do	102. 0	72	30	
Aug. 19, 1890	3, 310, 000	......do	10 per cent peripheral cocci; ½–1 per cent large parasites.	....	....do	104. 2	90	36	Urine free from hæmoglobin.
Aug. 20, 1890	3, 361, 000	......do	10 per cent peripheral cocci; ½–1 per cent large parasites.	Many macrocytes	....do	104. 3	90	30	
Aug. 22, 1890	2, 090, 000	One large parasite	10 per cent peripheral cocci; ½–1 per cent large parasites.	....do	....do	104. 8	108	32	
			5 per cent of large parasites.	Some macrocytes	Both punctated and tinted corpuscles.	100. 5	108	13	
Aug. 25, 1890 (9.30 a. m.) (1 p. m.)	1, 858, 000	Some large parasites. One bright body. ......do	5 per cent peripheral cocci. ......do (Plate VIII, figs. 2, 3.)	....do	....do	104. 4	120	.....	3 p. m. Pulse 132; evidently dying. Killed by a blow on the head.

Autopsy: Subcutaneous fatty tissue of ventral aspect of body from sternum to udder infiltrated with straw-colored serum. The infiltration several inches thick near udder. Blood clots quickly and firmly as it flows from the subcutaneous veins.

Slight ecchymosis of heart muscle. No degeneration of fibers. Numerous sarcosporidia cysts under endocardium. In blood from the right ventricle a few intraglobular parasites present. In principal lobe of right lung on convex surface six lobules in state of dark-red hepatization. Lung worms in bronchi.

Spleen weighs 3 pounds, moderately engorged. About 2 per cent of the red corpuscles contain the large paired parasites, some roundish, others pyriform.

Liver weighs 13¼ pounds. The cut surface presents a mottled (nutmeg) appearance. In fresh sections under the microscope large fat globules uniformly sprinkled over the section. No bile injection.

Sections of liver tissue (hardened in alcohol, imbedded in chloroform paraffin) stained in hæmatoxylin show more or less of pathological changes. The trabecular arrangement of the outermost zone of the lobule is exaggerated, the capillaries wide. The cells appear large and the protoplasm uniformly vacuolated. The nuclei are no longer normal. They appear as pale bodies with a stained periphery. The interior is disintegrated into a variable number of deeply stained roundish granules. In the central half of lobule the trabecular arrangement more or less effaced. The protoplasm is markedly vacuolated and the nuclei represented by three or more deeply stained granules which have shrunken together, in some cases coalesced into a single irregular mass. Capillaries do not show any red corpuscles.

Gall-bladder contains 1½ pounds of bile, very thick, dark colored and viscid. Holds in suspension an abundance of yellow amorphous flakes. In stained preparations of liver pulp about 5 per cent of the corpuscles contain one or more parasites. Kidneys somewhat pale (left weighs 1¼ pounds). No anatomical changes observable in fresh sections. In the capillaries and larger vessels of pyramids numerous corpuscles may be seen (×500) with the pale parasites within them. Occasional bunches of red needle-like crystals detected. In stained preparations few parasites within corpuscles, but a very large number of free bodies. In sections of tissue hardened in alcohol and stained in hæmatoxylin no pathological changes detected. Much fine pigment in convoluted tubules. Urine free from hæmoglobin; specific gravity, 1020; acid. No reaction for albumen, bile pigments, or bile salts.

Digestive tract normal with exception of fourth stomach, of which the mucosa has a pale bluish-red color. Much bile in duodenum. In red marrow from ribs perhaps 1 per cent of corpuscles contain one or two parasites.

No. 97 (native).—Bull calf of cow No. 50, born July 20, 1889.

September 14.—Placed with cow No. 50 in field IV (North Carolina cattle without ticks).

November 27.—No symptoms of disease observed up to date.

August 25, 1890.—Placed in field I to test presence or absence of infection of 1889. (See 74, 91.)

November 3.—No result to date. Animal removed. (For temperature record, see pp. 273, 274, and 275.)

No. 100.—May 10, 1890. Born to-day of cow No. 69.

July 4.—Exposed with No. 69 in field VI (North Carolina cattle with ticks).

October 11.—One tick found on animal. Temperature, 102.6; pulse, 72; respiration, 36. Red corpuscles, 4,393,000. In fresh preparations many corpuscles appear enlarged. Stained, not less than 10 per cent contain the small peripheral coccus-like bodies.

October 15.—A few small ticks on animal. Temperature, 104; pulse, 90; respiration, 42. Red corpuscles, 3,685,000. In fresh preparations a few corpuscles observed with a minute, pale, round body within each, near periphery. (Such bodies had also been observed in the preceding examination.) In stained preparations proba-

bly 15 per cent of all corpuscles contain the peripheral coccus-like bodies, seen in the fresh preparations as pale round bodies.

October 22.—Temperature, 103.8; pulse, 68; respiration, 22. Corpuscles, 3,254,000. In fresh preparations a bright and a pale intraglobular body detected. In stained preparations about 5 per cent of the corpuscles contain peripheral cocci.

November 13.—Temperature, 100.8; pulse, 64; respiration, 12. Animal emaciated and weak. A few lice observed. Corpuscles, 3,379,000. Some enlarged. Only about 1 per cent of corpuscles carry parasites.

November 24.—Temperature, 103.4; pulse, 84; respiration, 9. Corpuscles, 2,760,000, In stained preparations infected corpuscles rare. Animal very weak.

December 2.—Animal has been lying down, unable to move, since November 30. Probably dying. Temperature, 88; pulse, 42; respiration, 8. Corpuscles, 3,057,000. After long search several infected corpuscles detected in stained preparations.

December 3.—Animal killed by a blow on head. At the autopsy no lesions were observed excepting the presence of numerous lung worms in the bronchi and an œdematous condition on the submucous tissue of the fourth stomach. (For temperature record, see pp. 279 and 280.)

No. 101 (native).—Heifer, one year old, received May 31, 1890, from the District of Columbia.

July 4.—Placed in field IX (North Carolina soil only).

August 14.—Temperature, 101.6; pulse, 68; respiration, 30, Corpuscles, 5,600,000.

September 2.—Temperature 101.7; pulse, 60; respiration, 30. Corpuscles, 8,475,000. A few bright bodies detected within red corpuscles. Blood elements normal.

September 18.—Urine collected and examined. Normal. Blood also examined. After a long search one motile bright body detected within a red corpuscle.

November 3.—No symptoms of disease noticed up to date. (For the temperature record, see pp. 281 and 282.

No. 102 (native).

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature record, see pp. 281, 282 and 286.)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
Aug. 27, 1890	4,000,000	None	Negative	Some macrocytes		102.7	78	24	Cow, 6 years old, received May 31, 1890, from Montgomery County, Md, July 4, 1890. Exposed in field VIII (Cattle ticks only).
Sept. 18, 1890	1,950,000	Crenated	do	Many macrocytes		103.1			Aug. 25–Sept. 1. Very sick, temperature fluctuates. Loss of flesh rapid. Gives birth to a living calf (No. 102_a) at full term Sept. 1.
Oct. 4, 1890	2,672,700	None	do	do		102.5	72	24	Animal well covered with ticks of different sizes. Urine normal. Alkaline. Sp. gr., 1024.
Oct. 17, 1890	3,894,700		do	Some macrocytes		104.9	72	66	Oct. 15. Transferred to field IV. (For convenience of
Nov. 6, 1890	5,120,000	One bright body	do	Very few macrocytes.		102.7	66	24	examination merely.)
									July 2, 1891. Continued to improve during the winter and is now in fat condition. Reëxposed in field VI (North Carolina cattle with ticks).
Sept. 7, 1891	4,850,000 (white 14,000)		do			101.4	56	44	Very many ticks on animal.
Oct. 6, 1891	4,170,000 (white 15,094)	None	do	Normal	Normal	100.2	72	27	Ticks diminished in number. Animal in good condition.
Oct. 31, 1891	4,878,000 (white 10,606)		do	do	do	101.2	80	40	Dec. 25. Gives birth to calf. Condition has remained good during exposure, although there were many ticks on animal.

No. 102 a (*native*).—Calf of No. 102. Born September 1, died September 13, kept in refrigerator until September 15. The examination was delayed because of other work. It was presumed that the calf had succumbed to other causes, but to our surprise the autopsy demonstrated a marked case of Texas fever as the following notes will show.

Autopsy: Several small ticks found on skin of thighs. The subcutaneous as well as visceral fat over the whole body has a decided yellow tinge.

Heart empty, contracted. Fatty degeneration of fibers. Spleen (weight 13 ounces) was dark, enlarged and softened. Liver ($1\frac{3}{4}$ pounds), firm, brownish red. In fresh sections and teased preparations fatty degeneration of the hepatic cells moderate; nuclei distinct. Occasional spots showing bile injection. Considerable number of minute golden needle-like crystals scattered over the section. In stained preparations about 10 per cent. of the red corpuscles in the liver contain each a pair of parasites. Bile thick and full of flaky sediment. Not so dark in color as with adults. Kidneys very hyperæmic, of a dark brownish-red color. In fresh sections capillaries distended with red corpuscles. About 20 per cent. of corpuscles invaded by parasites.

About 500 cc. (1 pint) of urine in bladder deeply colored with hæmoglobin, not translucent in layer $\frac{3}{4}$ inch deep. Specific gravity, 1022. Reaction, acid. 1.4 per per cent. albumen (Esbach.)

No. 103 (*native*).—Heifer, three years old, received June 4, 1890, from Prince George County, Md.

July 4.—Placed in field VII (North Carolina cattle without ticks. Ticks washed in later from adjoining field VIII.)

August 16.—Temperature, 102.8. Corpuscles, 5,500,000. Nothing abnormal in fresh and stained preparations.

August 25.—Temperature, 103; pulse, 60; respiration, 25. Corpuscles, 5,133,000. In fresh preparation 5 corpuscles observed containing each a motile, bright body. In stained preparations nothing abnormal.

September 6.—Found dead this morning quite unexpectedly.

Autopsy at noon: A large number of ticks of all sizes on the animal.

Heart: Slight ecchymosis on pulmonary artery, near root. Small quantity of fluid blood in both ventricles. Considerable extravasation under endocardium of left ventricle. In fresh preparations of heart's blood a considerable number of bright bodies within corpuscles, in motion and of pale round forms, equal to about one-third or less of the diameter of the containing corpuscles. In stained preparations corpuscles containing one or two parasites, distributed more or less in groups.

Lungs œdematous.

Spleen weighs $3\frac{1}{2}$ pounds. Pulp very dark, partly disintegrated. In stained preparations from 5 to 10 per cent. of corpuscles infected with parasites.

Liver weighs 12 pounds. Color more yellowish than normal, slightly mottled in appearance. Slight fat infiltration, with general engorgement of capillaries with corpuscles, but no bile injection. In stained preparations, from 15 to 20 per cent. of the corpuscles contain each one or two parasites. Bile in bladder very thick, and flows like sirup, leaving a golden brownish coating on vessels. Large quantity of suspended solids.

Kidneys have a uniform brownish-red color on section. In fresh sections capillaries in general distended with corpuscles. In stained preparations not less than 50 per cent. of those contain one or two parasites. Urine of a deep port-wine color. Specific gravity 1017; faintly alkaline. Albumen present in slight amount.

Digestive tract normal, with exception of fourth stomach, the mucosa of which is dark pink in color. In the duodenal portion there are erosions, with blackish base $\frac{1}{8}$ to $\frac{1}{2}$ inch long.

In uterus a fœtus seven to eight months old.

In marrow from the ribs a small number of parasites detected. (For the temperature record, see p. 281.)

No. 104 (native).

[Heifer, 3 years old; received June 4, 1890, from Prince George Co., Md. July 4, exposed in field IX (containing North Carolina soil only).]

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature record, see pp. 281, 282, and 286,)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
Oct. 15, 1890	5,940,000	Some bright bodies	Negative	Normal	Normal	101.5	51	21	Oct. 28. No symptoms of disease have been observed.
July 2, 1891	......	......	......	......	......	......	....	....	Exposed in field VI (North Carolina cattle with ticks).
Aug. 13, 1891	6,900,000	Negative	Negative	Normal	Normal	102.2	66	48	Has been affected with a diarrhea for some weeks past.
Aug. 22, 1891	4,440,000	do	do	do	do	107	93	93	
Aug. 24, 1891	2,773,000	Some bright bodies	A few large parasites	do	do	104.5	102	48	
Aug. 26, 1891	2,937,500	Negative	Negative	do	do	100.7	74	21	Animal very weak. Scarcely able to rise from the ground.
Aug. 29, 1891	2,762,000	do	do	Some macrocytes	Some punctated and tinted corpuscles.	100.3	66	15	
Sept. 8, 1891	2,400,000 (white 11,666)	......	do	30 per cent macrocytes	......	102.6	72	42	Many ticks on animal.
Oct. 8, 1891	3,338,000 (white 10,769)	Negative	do	Slight variations in size.	......	102.4	80	36	
Oct. 31, 1891	2,103,000 (white 10,377)	......	5 per cent peripheral cocci.	Many macrocytes	Many punctated corpuscles.	101.5	72	36	
Nov. 3, 1891	......	Some bright bodies	Negative	50 per cent macrocytes	30 per cent of punctated and tinted corpuscles.	......	....	....	
Nov. 12, 1891	2,524,000 (white 11,111)	......	1 peripheral coccus	Many macrocytes	No punctated and tinted corpuscles.	103	80	40	
Nov. 17, 1891	3,105,000 (white 15,789)	......	5 per cent peripheral cocci.	......	......	100.7	78	30	
Nov. 24, 1891	3,236,000 (white 16,363)	......	Fewer peripheral cocci.	......	......	102	88	32	No ticks after careful examination.
Dec. 7, 1891	4,048,000 (white 11,290)	......	1 per cent peripheral cocci.	......	......	101.9	80	28	Dec. 21. Animal still in poor condition.

No. 105 (native).

[Heifer, 2 years old; received from Prince George County, Md., June 4, 1890. July 4, exposed in field VIII (North Carolina cattle ticks only).]

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature record see pp. 281, 282, 286, and 290.)
		In fresh preparations,	Dried and stained.	In fresh preparations.	Dried and stained.				
July 29, 1890	5, 525, 000	None	None	Normal	Normal	......	....	....	
Aug. 4, 1890	6, 244, 000	do	do	do	do	......	....	....	
Aug. 14, 1890	5, 120, 000	do	do	do	do	105. 4	60	45	
Aug. 16, 1890	4, 774, 000	do	2–3 per cent contain large parasites.	do	do	106. 9	93	32	
Aug. 19. 1890	1, 979, 000	A few large parasites.		do	A very few punctated cells	105. 3	108	36	Aug. 18. Animal considerably emaciated and weak. Has no appetite.
Aug. 20, 1890	2, 040, 000	None	None	A few macrocytes.	Some punctated and tinted corpuscles.	102. 5	94	24	Transferred to field IV (for exposure of healthy to sick natives).
Aug. 21, 1890	1, 962, 500	do	do	Macrocytes increasing.	Punctated and tinted corpuscles more numerous.	104. 8	96	27	
Aug. 22, 1890	1, 785, 700	A few bright bodies.	do	do	5 per cent punctated and tinted.	104. 8	98	64	
Aug. 27, 1890	2, 640, 000	None	One large parasite.	do	10–15 per cent punctated and tinted.	101. 3	54	30	A large number of adult ticks on animals.
Sept. 2, 1890	1, 910, 000	A few bright bodies.	None		1–2 per cent punctated and tinted.	102. 5	54	28	
Sept. 13, 1890	2, 762, 000	None	A few peripheral cocci.	Many macrocytes.	Many macrocytes.	102	96	36	Only two adult ticks observed. Urine very pale, barely alkaline. Sp. gr. 1004; no albumen.
Sept. 24, 1890	2, 724, 000	do	5–10 per cent peripheral cocci.			101. 8	66	30	A few half grown ticks observed.
Oct. 6, 1890	2, 636, 000	do	10–15 per cent peripheral cocci.		Some macrocytes.	101	78	24	
Oct. 14, 1890	2, 775, 000	do	10 per cent peripheral cocci.		do	102. 5	60	27	
Nov. 6, 1890	4, 305, 000	do	Peripheral cocci very scarce.		Normal	103. 1	63	48	
Nov. 19, 1890	5, 193, 000	do	do			102. 2	56	28	Has been improving slowly during past 30 days. Dec. 31, 1890. Nearly recovered as to general condition.
Sept. 5, 1891	5, 757, 000 (white 11, 111)	do	None	Normal	Normal	102. 1	66	48	Reëxposed to-day in field VI (North Carolina cattle with ticks).

No. 105 (native)—Continued.

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks.
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
Oct. 8, 1891	4, 724, 000 (white 12, 069)	....	None	Normal	Normal	101. 8	48	76	Dec. 12. Gives birth to calf No. 192. Dec. 21. Result of this exposure negative.
Nov. 4, 1891	5, 200, 000 (white 11, 428)	....	...do	...do	...do	101. 2	80	48	
Aug. 26, 1892	5, 962, 500 (white 18, 750)	....	...do	....	...do	102. 4	66	38	Reëxposed in field VI (North Carolina cattle with ticks).
Sept. 21, 1892	2. 775, 000 (white 10, 000)	....	...do	....	30 to 40 per cent macrocytes. 10–20 per cent punctated and tinted.	102	72	[illegible]	
Sept. 22, 1892	2, 800, 000 (white 13, 414)	....	....	....	....	101. 6	80	28	
Oct. 10, 1892	3, 800, 000 (white 5, 555)	....	....	Many macrocytes.	....	102	60	40	Has passed through a mild attack.

No. 106 (native).—Heifer, 2 years old, received June 4, 1890, from Prince George County, Md.

July 4.—Exposed in field VII (North Carolina cattle without ticks. Ticks washed in from adjoining field VIII. See No. 103).

August 25.—Temperature, 105.9; pulse, 72; respiration, 48. Red corpuscles 6,175,000. In preparations of fresh and stained blood a very few corpuscles observed with intraglobular bodies rather irregular in outline.

August 27.—Temperature, 105.8; pulse, 72; respiration, 48. Corpuscles 3,400,000. Corpuscles in fresh preparations mostly crenated. In stained preparations from 5 to 10 per cent contain large pyriform parasites in pairs or else smaller roundish bodies singly or in pairs. (Plate V, Fig. 2.) Skin almost bloodless. Blood obtained from incisions with difficulty and in very small quantities.

August 28.—Found dead this morning. Seen alive at 6:30 the preceding evening.

Autopsy at 9:30 a. m.: Animal in good condition. Emaciation very slight. To skin of abdomen, neck, and inner surface of thighs a large number of small ticks are attached. On opening the abdomen a distinct odor of decomposition noticeable.

Heart surface sprinkled over with minute petechiæ, most numerous near the base. In both ventricles small clots and some liquid blood which contains about the same number and kind of parasites as those observed yesterday in blood from the skin. Some large bacilli present. A few patches of extravasation beneath the endocardium of left ventricle and one on mitral valve. A similar patch on one of tricuspid valves. Lungs slightly emphysematous; lungworms absent.

Spleen weighs 3½ pounds. Pulp dark, soft, very much engorged with blood corpuscles. Much pigment within large cells and free. In stained preparations from 10 to 20 per cent of all corpuscles contain single or paired parasites irregularly roundish and from ¾ to 1 μ in diameter. Bacilli present.

Liver weighs 11½ pounds. Enlarged, yellowish brown on surface and section. Yellowish zones visible to naked eye bordering the minute vessels. In fresh sections the bile capillaries are injected with bile in the central portion of lobule. (Plate II, Fig. 4.) Fatty degeneration slight. In stained preparations fully 50 per cent of all corpuscles contain single or paired parasites. Some large bacilli likewise detected. In sections of tissue hardened in Müller's fluid and alcohol and cut in alcohol without imbedding no structural changes are observed. The bile injection is well brought out over the whole area of some of the lobules.

About ¾ pound of bile in gall bladder, which holds a large quantity of solids in suspension.

Kidneys deeply congested throughout. Occasional petechiæ in cortex. In fresh sections all capillaries distended with red corpuscles in which very few parasites can be distinctly seen in this way. Nevertheless in stained preparations fully 50 per cent of all corpuscles are found to contain parasites. Bacilli present.

About one quart of urine in the bladder. This has a deep port-wine color, barely translucent in layers an inch deep. When diluted with 2 parts of water it assumes a beautiful wine-red color in the test tube with transmitted light. Specific gravity 1022; feebly acid. 1.4 per cent albumen present.

Digestive tract not materially affected. Much bile in duodenum and parasite nodules in walls of ileum. Some patches of extravasation on mucosa of rectum.

In the marrow of ribs many hæmatoblasts with 2 to 5 nuclei. (For the temperature record, see p. 281.)

No. 107 (native).

[June 6, 1890.—Heifer one year old, received to-day from the District of Columbia. July 5, exposed in field II (Texas cattle with ticks).]

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature record, see pages 274, 276.)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
Aug. 22, 1890	7,343,000	Some bright bodies ...	None	Normal	Normal	102.5	50	28	
Aug. 23, 1890	6,891,000	None	......do........	....do........	....do........	104.8	72	27	
Aug. 25, 1890	4,175,000	A few bright bodies (Plate VI, Fig. 10).	A few large parasites.	....do........	....do........	104.5	96	48	
Aug. 27, 1890	3,054,500	....	None	....do........	....do........	104.2	90	24	September 10.—Has become very weak and thin since August 20.
Sept. 11, 1890	3,192,000	None	......do........	Many macrocytes.	Many macrocytes.	101.2	90	90	A small number of ticks of all stages.
Sept. 20, 1800	4,505,000	......do........	......do........	....do........	....do........	103	....	....	
Sept. 30, 1890	4,077,000	Several bright bodies.	......do........	....do........	....do........	102.4	72	24	
Oct. 11, 1890	4,595,000	None	10-15 per cent peripheral cocci.	Normal	Normal	102.8	78	54	Relapse or second infection as shown by the blood examination.
Nov. 11, 1890	3,410,714	......do........	1-2 per cent peripheral cocci.	Many macrocytes.	....	101	72	15	
Nov. 26, 1890	4,155,000	......do........	......do........	....	....	103.6	84	36	December 1.—Has been recovering very slowly since September 10. Still thin.

No. 108 (*native*).—Heifer, 2 years old when received, June 7, 1890, from the District of Columbia.

The blood of this animal was examined June 18, 1890. The corpuscles number 7,808,000.

July 4.—Exposed in field VII (North Carolina cattle without ticks. Ticks washed in from adjoining field VIII. See Nos. 103, 106.)

September 9, 1890.—Died during the night. In fair condition as to flesh. Weighs between 500 and 550 pounds. A large number of ticks of all stages attached to body.

Heart: Muscular tissue rather pale. Faintly granular appearance of fibers under microscope. In right ventricle and auricle a rather firm dark clot extending into the large vessels. The left side contracted. The blood, examined fresh, contains many macrocytes and a few hæmatoblasts. A certain number of corpuscles contain rather large parasites. In stained preparations 5 to 10 per cent of the corpuscles are infected. A small number of the corpuscles are quite large and uniformly tinted. No punctated cells detected.

Lungs œdematous, only partly collapsed.

Spleen weighs 3⅝ pounds. Enlarged, but still firm. Malpighian bodies visible. In teased preparations many large corpuscles, but no hæmatoblasts detected. Very little pigment.

In stained preparations 10 to 20 per cent of corpuscles contain one or two rather large, roundish parasites 2 μ in diameter.

Liver weighs about twelve pounds and has a uniformly brownish yellow appearance, due to the extensive injection of the bile-capillaries with bile. Much fatty degeneration associated with this injection. Ten to 20 per cent of the corpuscles contain parasites. Bile very thick and flaky.

In stained preparations from the kidneys about 30 per cent of all corpuscles contain one or two parasites. A few large bacilli present and some hæmatoblasts.

Urine in bladder (about 2 quarts) is of a port-wine color. Specific gravity 1013. Slight precipitate when acidified and boiled.

Digestive tract: Mucosa of fourth stomach has a few erosions, with a partly yellowish, partly blackish base. Some sand and gravel mixed with the food. In pyloric portion some round worms. Mucosa of duodenum pigmented in points and striæ. Worm tubercles in wall of ileum. In cæcum many firm fæcal balls, covered with mucus.

The red corpuscles of the marrow infected as in spleen and liver. (For temperature record, see pp. 281 and 282.)

No. 109 (*native*).—Cow, 10 years old when received, June 7, 1890, from the District of Columbia.

August 25.—Placed in field V to be exposed to blood and splenic pulp from natives which had died of Texas fever. This had been scattered over the ground.

September 18.—Temperature 101.6. Red corpuscles 5,726,000. In fresh preparations they appear normal. Within, several minute, bright, short rods present. In stained preparations corpuscles are normal and parasites absent.

October 3.—Temperature, 102.2; pulse, 54; respiration, 48. Red corpuscles, 6,190,000. In fresh preparations corpuscles normal. In every five or six fields one containing a motile bright body detected. Stained preparation as above.

October 14.—Temperature, 100.5; pulse, 48; respiration, 24. Red corpuscles, 5,807,000. Condition of corpuscles in fresh preparation as before. Motile bright bodies perhaps more numerous. Stained preparation as above.

November 3.—Result of exposure negative. (For temperature record, see p. 283.)

No. 110 (*native*).—Heifer, 1 year old when received, June 9, 1890, from Charles County, Md.

August 14.—Placed in a box-stall and fed several thousand young ticks and egg cases, weighing in all about 4⅝ grams. Feeding negative. (See temperature record on p. 283.)

No. 111 (*native*).—Heifer, 18 months old when received, June 9, 1890, from Charles County, Md.

September 1.—Blood was taken at noon from one of the jugular veins of No. 128, just dead, whipped with sterile glass rods and kept in warm chamber until 3 p. m., when 13 cc. of it was injected into the right external jugular vein of No. 111. The operation was performed by laying bare the vein, then piercing its walls with the needle of the syringe, and injecting the defibrinated blood. Placed in field I (see Fig. 5) after the operation. The following table shows in the reduction of the number of corpuscles that a mild form of the disease was produced:

No. 111 (*native*).

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature record, see pages 274, 275.)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
Sept. 9, 1890	4,461,500	None	None	Crenated		105.7	90	120	
Sept. 13, 1890	2,907,700	One bright body	A few doubtful forms.			102.7	84	48	
Sept. 16, 1890	4,116,600	None	None	Crenated	Many macrocytes	102			
Sept. 22, 1890	4,100,000	do	do	do	do	100.2	54	30	
Sept. 30, 1890	3,712,000	do	do	do	Few macrocytes	101.2	63	36	
Oct. 4, 1890	4,350,000	do	do		do	101.2	78	48	
Oct. 11, 1890	3,980,700	do	do	Crenated	Normal	100.5	60	36	
Oct. 22, 1890	3,635,000	do	do		do	100.5	54	14	
Nov. 8, 1890	3,621,000	do	do	Shriveled	do	102.2	66	12	Heifer has grown very thin, dull; lying down much of the time. Emaciation going on since September 10.
Nov. 24, 1890	3,254,000	do	do	Crenated	do	102.6	72	15	Emaciation continues.
Dec. 11, 1890	3,550,000	do	do	do	do	98.5	60	12	Skin almost bloodless. Animal lying since yesterday unable to rise. Greatly emaciated. December 17, has been lying since December 10 in the same position. Occasionally chewing the cud until December 14; found dead this morning.

Autopsy: Animal very thin and the tissues quite anæmic in appearance.

In abdominal cavity considerable œdema of mesentery and connective tissue around kidneys.

Lungs œdematous. A few small areas are emphysematous. In both sides of the heart large firm clots (larger in right), partly pale, extending into the large vessels.

Spleen small, unchanged. No pigment in pulp. Liver weighs 4½ pounds, with gall-bladder. In general normal in appearance. About 6 ounces viscid bile with much flocculent matter. Kidneys normal. Urine in bladder clouded, free from hæmoglobin and albumen.

Digestive tract. Much œdema of submucous coat of fourth stomach especially in the laminated portion. The mucosa has a markedly pink color in patches. Other portions of the tract normal. In the blood and organs no trace of the Texas fever parasite.

No. 112 (Southern).—Cow from near New Berne, N. C., age 12 to 15 years. Received July 4, 1890. Placed in field VI. This cow is very thin and weak. Neck and inner aspect of thighs loaded with ticks.

July 8.—Temperature 105.2. Corpuscles 2,786,000. In preparations of fresh blood, a slight tendency towards distortion and increase in size noticeable. No corpuscles detected in stained preparations indicative of a recent acute attack of Texas fever. No parasites present.

July 15.—Corpuscles 3,095,000. Owing to the enfeebled condition of this animal it was killed. It was likewise hoped that some information might be obtained by a post-mortem examination of a Southern animal at this time.

Autopsy: At apex of heart the wall of left ventricle thinned out to a translucent membrane which can be pushed out with the finger and withdrawn. Under endocardium a large number of sarcosporidia cysts. Lungs contain a few small firm subpleural nodules; otherwise normal.

Spleen weighs ¾ pound, small and firm; microscopically nothing abnormal in teased preparations. No parasites detected in stained preparations.

Liver weighs, without gall bladder, 6 pounds. Minute, ocher-yellow dots and lines, noticed on the cut surface and associated with the central vein of the lobule, are found to be due to advanced fatty changes of the hepatic cells in this situation. Among the fat débris are round, reddish spheres slightly larger than red corpuscles. In sections from alcoholic material stained in carmine and in hæmatoxylin, small pale areas are seen around the central vein of some of the lobules in which cells contain very large vacuoles. The nucleus is contracted and pushed to periphery of cell. In the carmine section considerable pigment is observed in granules.

Digestive tract: In the fourth stomach mucosa is more or less pitted by *Strongylus Ostertagi*. The minute holes surrounded by a slightly thickened border. In the lower small intestine and cæcum the walls studded with numerous worm tubercles.

No. 113 (Southern).—Cow, 3½ years old. Received September 14, 1889, from near New Berne, N. C., and placed in Field III (North Carolina cattle with ticks).

November 27.—Removed from field.

No. 114 (Southern).—Heifer 2 years old. Received July 4, 1890, from near New Berne, N. C., and placed in Field VI (North Carolina cattle with ticks).

November 3.—Removed from field and sold.

No. 115 (Southern).—Cow, 6 years old. Received July 4, 1890, from near New Berne, N. C., and placed in Field VII (North Carolina cattle without ticks) after the ticks had been carefully picked off.

July 13.—Gives birth to calf.

October 20.—Removed and sold.

No. 116 (Southern).—Heifer, 2 years old. Received July 4, 1890, from near New Berne, N. C., and placed in Field VII (North Carolina cattle without ticks) after the ticks had been carefully picked off.

November 3.—Removed from field and sold.

No. 117 (Southern).

[Heifer 2 years old. Received July 4, 1890, from near New Berne, N. C., and placed in field VII after the ticks had been picked off.]

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature record, see pp. 284, 285.)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
Nov. 19, 1890	6,333,000					102.4	64	32	Placed in box stall in stable with No. 145. Temperature of stable kept between 65° and 80°F.
Nov. 24, 1890	5,580,000	None	None	Normal	Normal	102.3	52	60	
Nov. 28, 1890	6,096,700	One bright motile body	do	do	do	102.6	68	60	From November 21 to December 3 about 200 ticks, hatched artificially, placed on the animal every other day. (For source of ticks, see No. 145.)
Dec. 5, 1890	5,100,000	None	do	do	do	102.2	76	60	
Dec. 8, 1890	5,500,000	do	One large pyriform body and one peripheral coccus.	do	do	102	64	66	
Dec. 15, 1890	5,328,000	do	None	do	do	101.2	72	36	Dec. 13.—The first mature ticks observed to-day.
Jan. 16, 1891	5,300,000	do	do	do	do	102.2	68	48	
Jan. 22, 1891	5,726,000	One bright body	do	do	do	101.5	72	52	Remained in stable until April 13, 1891. General condition at this date better than at beginning of experiment

No. 118 (*Southern*).—Cow, 10 years old; received July 4, 1890, from near New Berne, N. C., and placed in field VII (North Carolina cattle without ticks) after the ticks had been carefully picked off.

November 3.—Removed from field and sold.

No. 119 (*Southern*).—Calf, 3 months old; received July 4, 1890, from near New Berne, N. C., and with its dam, cow No. 120 placed in field VI (North Carolina cattle with ticks).

November 2.—Removed from field and sold.

No. 120 (*Southern*).—Cow, 7 years old; received July 4, 1890, from near New Berne, N. C. Placed in field VI on that day.

September 21.—Dies about 3 p. m. to-day. Had been bloated for several days. Examination postponed till next morning, at which time decomposition was already advanced. There was found extensive exudative peritonitis.

No. 121 (*Southern*).—Cow, 3 years old; received July 4, 1890, from near New Berne, N. C. Placed in field VI on this day.

September 2, 1890.—Temperature, 102.6; pulse, 106; respiration, 42. (Greatly excited on being caught). Corpuscles, 6,683,000. Nothing abnormal detected in fresh preparations of blood. In one stained preparation about 12 peripheral coccus-like bodies detected. Urine passed at the time normal.

September 28.—Gives birth to calf, No. 148.

July 2, 1891.—Exposed in field VI to Southern cattle with ticks.

October 20.—No evidence of infection up to date. (For temperature record, see p. 286.)

No. 122 (*Southern*).—Heifer, 2 years old, received July 4, 1890, from near New Berne, N. C., placed in field VI.

September 2, 1890.—Temperature, 103.9; pulse, 88; respiration, 56. (Considerably excited on being caught.) Corpuscles, 5,737,000. Nothing abnormal detected in fresh preparations of blood. In two stained preparations a marked variation in the size of the red corpuscles noted (5 to 8 μ.) Two peripheral coccus-like bodies and one large parasite found after a long search. Urine passed at the time normal.

No.123 (*Southern*).—Heifer, 3 years old. Received July 4, 1890, from near New Berne, N. C., and placed in field VII (North Carolina cattle without ticks) after ticks had been carefully removed.

November 3.—Removed from field and sold.

No. 124 (*Southern*).—Cow, 4 years old, received July 4, 1890, from near Houston, Tex., and placed on this day in field II.

September 11, 1890.—Temperature 103. Corpuscles 7,482,000. In fresh preparations of blood several bright motile bodies observed within corpuscles. Two appeared as mere refrangent points and two had a rodlike form. In a stained preparation no parasites detected after a long search. Red corpuscles vary slightly in size. A small number of ticks of various sizes on this animal.

No. 125 (*Southern*).—Heifer, 3 years old. Received July 4, 1890, from near Houston, Tex., and placed in field II (Texas cattle with ticks).

November 3.—Removed from field and sold.

No. 126 (*Southern*).—Cow, 5 years old. Received July 4, 1890, from near Houston, Tex. Placed in field II on this day.

July 10.—Temperature 100.8. Corpuscles 5,947,000. No abnormal forms in stained preparations.

September 11.—Corpuscles 6,383,000. Somewhat variable in size. In fresh preparations one doubtful bright body observed. In several preparations no abnormal forms detected. Ticks of various stages on animals.

July 2, 1891.—Exposed in field VI to southern cattle with ticks.

October 20.—No indication of infection up to date. (For temperature record, see p. 286.)

No. 127 (*Southern*).—Heifer, 2 years old. Received July 4, 1890, from near Houston, Tex., and placed in field II (Texas cattle with ticks).

November 3.—Removed.

No. 128 (*native*).—Cow, 12 to 14 years old. Received July 4, 1890, from the District of Columbia, and exposed in field II, to Texas cattle with ticks.

July 25.—Corpuscles 6,360,000. They appear normal in fresh and stained preparations.

July 29.—Corpuscles 5,673,000. Normal in fresh and stained preparations.

July 31.—Corpuscles 5,820,000. Normal in fresh and stained preparations.

September 1.—Dies at noon and examined at once.

Animal in fairly good condition. Weighs about 650 pounds. A small number of ticks of various stages attached to skin.

Blood from a skin incision examined a few minutes after death. In a considerable number of red corpuscles parasites singly or in pairs. The forms are mostly round, rarely spindle-shaped or pyriform, and their diameter is about one-third the diameter of the corpuscle. In several slight changes of outline observable. Besides these some corpuscles likewise contain each one bright body changing its position rapidly. In the fresh preparations are also noticed very minute bacteria-like bodies moving or dancing about free in the plasma. Whether these are mere débris particles in Brownian motion is not determinable. In stained preparations from 20 to 30 per cent of all corpuscles contain the parasite in its large stage. The majority of the infected corpuscles contain each but one body which is usually roundish rarely pyriform in outline. Occasionally, however, a group of corpuscles is encountered which contain each a pair of pyriform bodies. All parasites stain feebly and show more or less refrangence when examined in water.

Blood from the external jugular and the heart shows the same features.

Heart: Slight, mottled discoloration of muscular tissue of left ventricle. Considerable extravasation of blood under endocardium. Many sarcosporidia cysts in this situation. Muscular fibers in state of cloudy swelling.

Lungs: Considerable interlobular œdema in both ventral and adjacent portion of principal lobes. In the right principal lobe, near the lateral edge, a mass of tissue 1½ to 2 inches in diameter partially hepatized with interlobular effusion of serum.

Spleen large, weighs 4¾ pounds. Pulp dark, almost disintegrated. A few intraglobular parasites and much pigment in lumps, either free or intracellular observed in teased preparations.

Liver weighs about 12 pounds. Very much congested, parenchymatous swelling. Bile injection observed in restricted places, and fatty changes absent. Numerous infected corpuscles detected in teased preparations.

Kidneys also intensely congested, the whole parenchyma has a uniformly dark brownish-red color. In sections all capillaries gorged with corpuscles, in some of which parasites are noticed. The epithelium of the convoluted tubules contains much pigment in granules. Bladder contains about 3 quarts of urine, having a very dark port-wine color. In a test tube having a diameter of ¾ inch this urine is practically opaque. When acidified with acetic acid and boiled an abundant precipitate is formed.

Digestive tract. Mucosa of fourth stomach dark pink. Pits due to *Strongylus Ostertagi* present and numerous erosions with a depressed hemorrhagic base from ⅛ to ¼ inch in diameter. Considerable hyperæmia of the mucosa of the entire small intestine. Pigment patches in cæcum and hyperæmia in the rectum on the longitudinal folds.

This being a very favorable case, examined immediately after death, the following cultures were made:

Blood: Peptone-bouillon, peptone agar with and without glycerine.

Spleen: The same media.

Liver: Agar with and without glycerine.

Kidney: The same.

Bile: The same.

The tubes were inoculated from the blood and the bile with a looped platinum wire, from the organs with a straight platinum wire.

These various tubes were kept in the thermostat several weeks, but all remained sterile.

On the other hand, stained preparations of the various tissues show the following results as to the presence of the intraglobular parasite approximately stated:

Blood from the skin contains about 20 per cent of infected corpuscles. The parasites are largely in pairs and pyriform. Blood from the right heart contains about the same number. Blood from the jugular contains fewer (about 10 per cent).

Spleen contains from 10 to 20 per cent. of infected corpuscles. The parasites roundish, chiefly in pairs.

Liver contains from 40 to 50 per cent of infected corpuscles. These are also mostly in pairs and many are pyriform.

Kidneys contain between 80 and 90 per cent of infected corpuscles. These parasites are nearly all double. Some corpuscles contain three and four parasites. There are also an immense number of bodies set free from disintegrated corpuscles in this organ. (For temperature record, see pp. 274, 275, and 276.)

No. 129 (*native*).—Heifer, two years old. Received July 5, 1890, from the District of Columbia, and placed in field II (Texas cattle with ticks).

August 11.—Corpuscles 6,193,000. Nothing abnormal in fresh and stained preparations.

August 13.—Corpuscles 7,171,000. Microscopic examination as before.

August 16.—Temperature, 100.6; pulse, 60; respiration, 30. Corpuscles 5,370,000. Nothing abnormal detected in fresh and stained preparations.

August 27.—Temperatnre 106.6; pulse 96; respiration 30. Corpuscles 3,210,000. About 5 per cent of the red corpuscles contain peripheral cocci.

Heifer very weak. Barely able to move.

August 29.—Continues in the same condition. Temperature 101.2; pulse 100; respiration 30. Corpuscles 1,675,000. In fresh preparations on the warm stage a considerable number of corpuscles found to contain bright, motile bodies. One corpuscle found containing a large amœboid form. In stained preparations are found both peripheral cocci and slightly larger round bodies nearer the center of the corpuscle. About 5 per cent of corpuscles infected in this way.

August 30.—Heifer died at 8 p. m. yesterday. Weighs about 500 pounds. Considerably emaciated. Only a few ticks on body. Marked odor from the abdominal cavity when opened. Blood in subcutaneous veins liquid.

Heart: More or less extravasation on the left ventricle near base. In both sides clots of blood extending through both auricle and ventricle. Under endocardium of left ventricle much extravasation of blood, especially around and on papillary muscles. Cloudy swelling of fibers. Lungs collapse but slightly. More or less emphysema and œdema.

Spleen weighs 3½ pounds. Pulp dark, disintegrated. Wells out when capsule is incised. In teased preparations very few parasites detected. There are a considerable number of large coarsely granular cells containing red corpuscles or pigment.

Liver weighs about 11 pounds. Doughy to the touch. On section the parenchyma presents a markedly yellowish-brown appearance. Very extensive fatty degeneration of hepatic cells, which also contain more or less pigment. Bile canaliculi and small bile ducts largely plugged with solid bile.

Bile in gall bladder scarcely flows owing to the large quantity of flocculent material suspended in it.

Both kidneys congested uniformly throughout. In fresh sections capillaries found densely filled with corpuscles. Very fine pigment particles abundant.

Urine, about two quarts in bladder; has a deep wine-red color. Specific gravity 1013. Considerable brownish flocculent precipitate on boiling.

Digestive tract normal, with exception of upper small intestine, in which some patches of extravasation are found in mucosa.

In stained coverglass preparations the infection of the red corpuscles ran approximately as follows:

In heart's blood corpuscles are all shriveled. Parasites detected with difficulty. Probably 5 per cent infected.

In spleen about 10 per cent infected.

In liver about 20 per cent infected.

In kidneys over 50 per cent infected.

The parasites are all roundish, about 1 μ in diameter, many of them double.

In liver, kidney, and blood preparations there are also large bacilli with rounded ends. Each rod is 3–4 μ long and 1.5 μ broad. The post-mortem changes fully account for the presence of these bacilli. (For temperature record see pp. 274, 276.)

No. 130 (*native*).—Cow, 5 years old, received July 8, 1890, from Prince George County, Md.

July 9.—Placed in Feld I (see Fig. 5) to test survival of last year's infection.

October 28.—No evidence of infection up to date.

November 6.—Gives birth to a calf.

The following table gives the result of placing young ticks upon this animal in midwinter in an artificially heated stable. The experiment was begun December 12, and the table shows an attack of Texas fever beginning December 30.

No. 130 (native).

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature record see p. 285.)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
Dec. 11, 1890	5, 669, 000	Small number of motile bright bodies.	None	Normal	Normal	101.6	72	24	December 12.—Calf removed and cow placed in stable artificially heated for experiment with ticks. The secretion of milk stopped as fast as practicable.
Dec. 22, 1890	6, 330, 000	......do	......do	......do	......do	101.5	60	28	From December 13 to December 25 about 200 ticks artificially hatched were placed on back and neck every other day. On December 27 and 29 from 300 to 500 placed on animal. (See No. 152 for source of ticks.)
Dec. 27, 1890	5, 613, 000	......do	......do	......do	......do	102.2	72	44	
Dec. 30, 1890	4, 456, 000	Motile bright bodies more numerous. 1 per cent of large paired parasites.	1 per cent large paired parasites. (Pl. VI, Fig. 5.)	......do	......do	105.6	72	36	
Jan. 2, 1891	3, 164, 000	Some motile bodies, one pair large parasites.	......do	30 per cent macrocytes.	10 per cent punctated and tinted corpuscles.	101.7	80	40	
Jan. 6, 1891	2, 829, 000	A few motile bodies	Several large parasites	......do	30 per cent macrocytes.	......	....	....	From December 30 to January 2 almost entire loss of appetite with rapid emaciation. Has become very weak and staggers when moved in the stall.
Jan. 9, 1891	2, 284, 000	About 5 per cent bright motile bodies.	......do	Some macrocytes	A few punctate corpuscles.	103.2	80	28	January 3.—Appetite returning. Begins to improve generally. From January 3 to March 10 continues to improve and on the latter date entirely recovered and lost flesh regained. Continues in stable until April 13.
Jan. 16, 1891	3, 233, 000	Bright bodies almost disappeared.	None	......do	......do	101.5	72	36	
Jan. 20, 1891	3, 340, 000	......do	......do	......do	Some macrocytes	101.2	68	32	
Jan. 24, 1891	3, 658, 100	None	......do	......do	......do	101.2	80	28	
Jan. 29, 1891	4, 047, 600	......do	Two deeply stained round bodies, 1 μ diameter.*	......do	......do	101.5	52	24	
Feb. 5, 1891	4, 916, 000	Two bright motile bodies.	One deeply stained round body, 1 μ diameter.*	Normal	Normal	101.6	52	20	
Feb. 18, 1891	5, 680, 000	....	....	......do	......do	101.8	52	40	
Feb. 26, 1891	5, 649, 000	Several bright bodies.	None	......do	......do	101.6	52	32	
Mar. 10, 1891	6, 189, 000	......do	......do	......do	......do	101.5	52	24	
Mar. 18, 1891	6, 448, 000	......do	One deeply stained round body, 1 μ diameter.*	......do	......do	101.5	52	24	
Apr. 1, 1891	6, 636, 000	......do	......do	......do	......do	101.3	52	20	
Apr. 13, 1891	7, 220, 000	......do	None	......do	......do	100.8	54	18	

* These are probably remnants of the hæmatoblast nucleus.

July 2, 1891.—Reëxposed in field VI to Southern cattle with ticks.

August 25.—Temperature 107; pulse, 96; respiration, 54. Red corpuscles 3,922,000. In the fresh blood several corpuscles in every field of the microscope (estimated afterwards in stained preparations as 10 to 15 per cent of the whole) contain large parasites. These are either round or pyriform and some in pairs. The infected corpuscles have a dark-red color, the edges are irregular, and in general they have a wrecked appearance quite different from the corpuscles when crenated or wrinkled from external causes. Minute motile bodies not observed.

August 27.—Has been sick three days; failing very rapidly since yesterday. Has been lying down all the forenoon, excepting to change her position a few times, and then she moved 10 or 15 yards before settling down. At 1:15 p. m. she rose and staggered along 20 or 30 feet, then fell on her side and died soon after. Temperature shortly before death, 100.8° F.

Autopsy: Weight of animal 750 to 800 pounds. In fairly good condition. A considerable number of small ticks on escutcheon and thighs (from 8 to 12 to a square inch). A few on udder and neck.

Lungs slightly hyperæmic; trachea contains whitish foam. Heart: Considerable ecchymoses under endocardium of left ventricle, especially on and around papillary muscles. Heart muscle shows slight fatty changes.

Spleen weighs 6¾ pounds, enormously enlarged. The pulp is of a blackberry-jam color. (See Pl. I.) In teased preparations no pigment or phagocytosis of red corpuscles observed. Occasionally a roundish parasite with a dark point (nucleus?) within its substanee seen in red corpuscles.

Liver much enlarged, weighing 20 pounds. Color from the surface rather pale; texture somewhat flabby. On section a small quantity of thick blood flows from the hepatic veins. The parenchyma has a peculiar mottled appearance. The minute hepatic vessels are surrounded and sheathed by zones of a pale yellowish color. The intervening territory of a brownish-red color corresponds to areas containing much blood. Much bile injection observed (Pl. III, Fig. 1). Fatty degeneration everywhere noticeable with variable intensity.

About one pint of very thick, flaky bile in the gall bladder. Extensive deposit on standing.

Kidneys weigh each about 2½ pounds. The parenchyma has a uniform dark, brownish-red color throughout. The glomeruli appear as blood-red points. In fresh sections of cortex and medulla, the entire capillary system found gorged with blood corpuscles. Very few parasites detected by this method. In the medulla the straight tubules contain granular reddish pigment. In the bladder fully three quarts of dark-red urine, barely translucent in layers ¾ inch deep. Reaction alkaline. Sp. gravity 1020. Precipitate with acetic acid. About 1 per cent of albumen according to Esbach's test. Slight deposit of urates on standing in refrigerator, disappearing when heated.

Digestive tract. Mucosa of fourth stomach uniformly reddened. Scattered over it are small papular elevations, 1.5 mm. diameter, with central perforations. (Pits made by *Strongylus Ostertagi.*) Marked hyperæmia of jejunum and ileum. In the large intestine, the summits of the longitudinal folds are either hyperæmic or pigmented.

In uterus a fœtus 3 months old.

In the marrow from the sixth rib most hæmatoblasts have two nuclei, a few three and even four.

In stained preparations from the various organs and tissues the following percentage of infected corpuscles represents a rough estimate:

	Per cent.
Marrow from rib	5
Blood from subcutaneous veins	10–15
Blood from right heart	10–15

	Per cent.
Spleen	10–20
Liver	20–30
Capillary blood from heart muscle and omentum (Pl. VI, Figs. 1, 2)	50
Kidney (Pl. IV, Fig. 4)	60–80
Blood of fœtus, umbilical vein, none.	

The parasites were either round or pyriform, from 1 to 2 μ in diameter. Many were paired. In capillary blood the pyriform bodies more abundant than in the parenchyma of the organs. (For temperature record, see pp. 274, 275, 285, and 286.)

No. 131 (*native*).—Heifer, 2 years old, received July 8, 1890, from Prince George County, Md.

July 29.—Placed in box stall and fed 600 adult live ticks collected July 21–26 near New Berne, N. C. A large mass of eggs had been laid meanwhile. Of this mass a quantity weighing 70 grains was removed for hatching. A still larger quantity was fed with the ticks. The whole was fed after being mixed with lawn grass and mill feed.

August 12.—Fed 900 mostly adult live cattle ticks, collected August 4–7 inclusive, near New Berne, N. C. A mass of eggs weighing 330 grains was removed. A large mass remained which was fed with the ticks as before.

August 18.—Fed 500 adult ticks, mostly alive, with a mass of eggs weighing 200 grains. These had been collected at the same time with preceding lot.

September 30.—Removed from stable to field I (free from infection).

November 3.—No result to date. (For temperature record, see pp. 274, 275, and 283.)

No. 132 (native).

Date.	Number of red corpuscles.	Parasites in red corpuscles. In fresh preparations.	Parasites in red corpuscles. Dried and stained.	Condition of red corpuscles. In fresh preparations.	Condition of red corpuscles. Dried and stained.	Temperature.	Pulse.	Respiration.	Remarks. (For temperature record, see p. 283.)
Sept. 12, 1890	5, 435, 500	A moderate number of bright bodies.	None	Normal	Normal	101. 8	66	54	Heifer, 2½ years old, received July 18, 1890, from Prince George County, Md. Placed in Field IV (sick natives) on August 21.
Sept. 24, 1890	4, 862, 700	One bright body	......do	....do	....do	101. 4	48	30	Several ticks on thighs and udder.
Oct. 3, 1890	4, 150, 000	....	½ per cent peripheral cocci.	....do	....do	102. 4	60	30	No ticks observed.
Oct. 7, 1890	3, 592, 000	Several bright motile bodies.	None	....do	....do	100. 8	54	18	Do.
Oct. 18, 1890	4, 286, 000	None	......do	Considerable variation in size.	....	101	54	42	November 3.—Slight but appreciable loss of flesh during exposure.

No. 133 (native).

Date.	Number of red corpuscles.	Parasites in red corpuscles. In fresh preparations.	Parasites in red corpuscles. Dried and stained.	Condition of red corpuscles. In fresh preparations.	Condition of red corpuscles. Dried and stained.	Temperature.	Pulse.	Respiration.	Remarks.
Sept. 18, 1890	6, 172, 000	Several bright motile bodies.	None	Normal	Normal	101. 7	....	....	Heifer. 2½ years old, received July 18, 1890, from Prince George County, Md. Placed in Field IV (sick natives) on August 21. Urine strongly alkaline. Specific gravity, 1030. No abnormal constituents.
Sept. 30, 1890	4, 833, 000	......do	......do	....do	....do	101. 4	75	30	
Oct. 6, 1890	5, 587, 000	......do	10 per cent peripheral cocci.	....do	....do	102. 2	90	30	
Oct. 18, 1890	4, 358, 500	None	½ per cent peripheral cocci.	....do	Considerable variation in size. Several punctate corpuscles.	102. 2	90	48	
Nov. 1, 1890	4, 940, 000	One bright body	Peripheral cocci rare	....do	Some macrocytes still present.	102. 3	72	24	November 3.—Condition has been the same as that of No. 132.

No. 134 (*native*).—Heifer, 2 years old, received July 18, 1890, from Prince George County, Md.

August 13.—Exposed in Field VI (Southern cattle with ticks); kept up to this date in an uninfected field.

August 27.—Temperature, 106.4; pulse, 96; respiration, 36. Corpuscles, 2,213,000. In stained preparations of blood one-half to 1 per cent of red corpuscles contain large parasites.

The animal is at this date very much emaciated and weak. Has been sick for two days. A large number of ticks about one-eighth inch long attached to its body.

August 29.—Temperature, 97.4; pulse, 92; respiration, 28. Corpuscles, 1,840,000. Parasites are scarce in stained preparations, but punctate and tinted corpuscles have appeared; in fresh preparations a small number of corpuscles containing motile bright bodies and amœboid parasites.

Inasmuch as the animal was in a dying condition, it was killed by a blow on the head and the autopsy held at once.

Animal weighs about 450 pounds. Many small ticks on thighs and udder.

Heart: Diffuse extravasations beneath endocardium of left ventricle, especially marked near apex. In right ventricle extravasation slight. Myocardium not affected. Condition of blood the same as that from skin incisions.

Lungs normal.

Spleen weighs 2¼ pounds. Pulp dark brownish red and somewhat friable. Malpighian bodies still visible on the cut surface. (See Plate VII, Fig. 3.)

Liver weighs about 9 pounds. Appears enlarged. The surface reddish brown, with paler mottling along the course of minute veins. In fresh sections very extensive fatty degeneration observed. Each cell contains from 1 to 5 fat globules as large as red corpuscles. Bile injection observed in small, restricted areas. In fresh teased preparations corpuscles with large parasites readily detected.

About one pint of bile in gall bladder. It contains an abundance of flakes and mucus, so that it pours like very thick molasses, cohering in long flat bands as it leaves the vessel.

Kidneys on surface and section have a uniformly brownish-red color, with exception of tips of papillæ, which are somewhat paler. In fresh microscopic sections much granular pigment observed, some in the form of casts in the straight tubules.

In the straight vessels of cortex and medulla masses or plugs of red corpuscles may be seen, every one containing one or two large, roundish parasites. In a teased preparation in one field out of 11 corpuscles 4 contained pairs of pyriform parasites.

Urine reddish yellow. A slight flocculent precipitate forms on standing. Acid. Sp. gr., 1013. A small quantity of albumen present.

Digestive tract: Mucosa of fourth stomach has a faintly bluish color. The characteristic pits due to *Strongylus Ostertagi* present. Mucus in small intestine slightly increased in quantity. Cæcum thoroughly impacted with very dry fecal balls. The same condition of colon and rectum.

In stained preparations of spleen about 2 per cent of the red corpuscles contain single or paired pyriform bodies. Liver as many as 5 per cent.

Kidneys: An immense number of free parasites. Of the small number of corpuscles present fully 30 per cent contain pairs of pyriform bodies. (For temperature record, see p. 279.)

No. 135 (native).

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature record see pp. 281, 282, 289 and 290.)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
Sept. 5, 1890	3,416,000	....	One round body 1 μ diameter.	....	Normal	104.2	54	60	Heifer, 2 years old, received July 18, 1890, from Prince George County, Md. Exposed August 21 in Field VIII. (Ticks only.) September 8, very weak and emaciated. Liquid and fœtid diarrhea. Transferred to Field IV. (Sick natives)
Sept. 13, 1890	2,661,700	None	None	....	About 10 per cent macrocytes, one-half of which are either punctated or tinted.	102.7	84	60	
Sept. 24, 1890	3,200,000	....do	....do	Large number of macrocytes.	About 30 per cent macrocytes, no punctated or tinted forms.	102.2	54	48	A large number of ticks from adults down, on animal.
Oct. 3, 1890	3,622,600	....do	....do	....do	....do	102.2	72	36	Urine pale yellow. Sp. gr. 1035. Strongly alkaline. No albumen.
Oct. 15, 1890	3.910,700	One motile oval body..	One round body 1 μ diameter.	....	Macrocytes decreasing.	102.7	66	30	Several ticks on animal.
Nov. 6, 1890	4,803,000	One bright body	None	....	Macrocytes still present in small numbers.	102.4	60	16	December 1, has been slowly recovering since September 10; now nearly well.
Nov. 13, 1891	5,038,400 *1,524	....	....do	....	Normal	102.5	80	56	Not exposed this year.
July 20, 1892	....	....	....	....	....	......	....	....	Re-exposed in field VI (North Carolina cattle with ticks).
July 28, 1892	4,962,500 *7,500	Moderate number bright bodies.	None	Normal	Normal	102.6	116	68	
Aug. 22, 1892	4,225,000 *12,500	A few bright bodies ..	....do	....do	....do	102.2	72	84	
Aug. 31, 1892	2,056,250 *12,500	Several large parasites	About 6 single and 6 paired parasites.	....do	....do	102.6	108	90	October 8, this rather mild attack has made the animal quite thin.
Sept. 22, 1892	3,610,400 *6,500	....	None	Corpuscles generally enlarged.	....	100.5	56	24	

* White corpuscles.

No. 136 (native).

Date.	Number of red corpuscles.	Parasites in red corpuscles. In fresh preparations.	Parasites in red corpuscles. Dried and stained.	Condition of red corpuscles. In fresh preparations.	Condition of red corpuscles. Dried and stained.	Temperature.	Pulse.	Respiration.	Remarks. (For temperature record see p. 283.)
Sept. 30, 1890	3,911,300	A small number of bright motile bodies.	None	Normal	Normal	100.2	84	21	Cow, 5 years old, received July 20, 1890, from Prince George County, Md., placed in Field V. (See No. 109 for nature of exposure.)
Oct. 8, 1890	3,753,800	do	do	do	do	103.2	48	30	A grayish viscid discharge from vagina observed during defecation, made up of pus and blood corpuscles.
Oct. 18, 1890	3,735,300	One pale body seen	do	do	do	101.7	48	24	No. 3. Result negative so far as any symptoms of Texas fever are concerned.

No. 137 (native).

Date.	Number of red corpuscles.	Parasites in red corpuscles. In fresh preparations.	Parasites in red corpuscles. Dried and stained.	Condition of red corpuscles. In fresh preparations.	Condition of red corpuscles. Dried and stained.	Temperature.	Pulse.	Respiration.	Remarks.
Sept. 9, 1890	8,637,900	None	None	Normal	Normal	102.2	84	24	Heifer, 1 year old, received July 20, 1890, from Prince George County, Md., and kept in Field X (wood lot), containing only healthy cattle.
Sept. 22	5,166,600	do	1-2 per cent contain round and pyriform bodies.	Crenated	do	106.5	75	24	A large number (probably a few thousand) of ticks hatched 3 or 4 days ago placed on this animal to-day.
Sept. 24	3,509,400	do	1 pair pyriform bodies.	do	do	105	108	24	A large number of ticks attached to thighs (size of hemp seed).
Sept. 29	3,133,300	One motile bright body.	Several pairs pyriform bodies.	Some macrocytes	Some macrocytes	103.4	66	24	Ticks half grown present in large numbers.
Oct. 4	2,279,000		do	do	A few punctate and tinted cells; one hæmatoblast.	102.8	102	36	Some ticks full grown on October 1 found on thighs, udder, tail, neck, head, and ears.
Oct. 8	2,311,400	Several large amœboid forms.	do	Many macrocytes.	Many macrocytes	102.7	84	21	Many ticks have dropped off. October 12, animal very weak and thin. Lies down much of the time.
Oct. 15	3,264,000	Several parasites	None	do	do	102.8	75	18	A few ticks still on animal, which has grown very thin. Urine normal in color; alkaline; sp. gr. 1017. No albumen.
Oct. 25	2,897,000			Shriveled	A few macrocytes	103.6	63	18	
Oct. 30	2,806,000	Several large parasites.	Several pyriform bodies.	do	Normal	100.5	60	10	
Nov. 6	2,546,000	Some large parasites	1 per cent pyriform bodies. (Pl. VI, Fig. 7.)	do	do	97.4	60	9	

From October 25 the emaciation was extreme. It finally became so weak that it was unable to move. On October 30 it had been lying in one position for thirty-six hours past, chewing the cud incessantly, eating a little hay and drinking water freely. On November 2 it passes into a partly comatose condition. Eating and rumination have ceased. On November 6 it was killed by a blow on the head.

Autopsy: Extreme emaciation. Heifer weighs 200 pounds. Original weight about 350–400 pounds. A few small, and one nearly full grown tick still on animal. Œdema of the subcutis over the region of the sternum. Indications of fat absorption everywhere in the large cavities. Blood clots quickly and firmly.

Lungs normal. Heart somewhat flabby; fatty, and cloudy changes of fibers of left ventricle. Spleen weighs ½ pound, small, flabby. Malpighian bodies prominent. Much pigment in lumps found in teased preparations, both free and intracellular.

Liver, small; weighs about 4 pounds. In general pale and bloodless. Cells contain much pigment in form of minute granules. There are also a considerable number of cells observed in teased preparations up to 15 μ in diameter completely filled with lumps of brownish pigment. These are found quite uniformly distributed when sections are made.

Gall bladder contains nearly a pint (375 cc.) of viscid, dark bile, holding in suspension a moderate quantity of flakes.

Kidneys pale. No gross lesions observable. In sections of fresh tissue considerable pigment in lumps in glomeruli; in the epithelium generally much pigment in minute granules.

Urine from bladder yellowish, faintly alkaline. Sp. gravity, 1028. No albumen.

Digestive tract: Contents of fourth stomach smell badly. Considerable mucus on the membrane, which is beset with worm pits. Many worm modules in walls of ileum. In large intestine a considerable quantity of turbid liquid. Many specimens of *Œsophagostoma* in the rectum and upper colon imbedded in a mass of partly coagulated blood mixed with mucus.

In stained preparations of blood from the right heart, of spleen, liver, and kidney, one red corpuscle in every one or two fields of the microscope contains a pair of pyriform bodies. (For the temperature record, see page 283.)

No. 138 (native).

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature record, see page 283.)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
Aug. 30	7,015,000		None		Normal	105.3	90	30	Heifer, 1 year old, received July 20, 1890, from Prince George County, Md.
Sept. 3	6,655,500	Motile bodies, 5-6 in every field.	A few large parasites of irregular form.	Normal	do	103.8	72	24	August 14, placed in box stall and several hundred ticks just hatched placed on udder and thighs. The ticks from which the eggs were derived had been received from North Carolina July 29. The young ticks left the shell August 13. Young ticks were also added to this animal August 15 and 19, September 2 and 11.
Sept. 5	4,673,900		do	do	do	102.6	84	60	September 4, first adult ticks have appeared to-day.
Sept. 9	3,674,700	None	One pyriform body	Macrocytes	10 per cent macrocytes, one punctate corpuscle.	102.1	96	54	A large number full-grown to-day.
Sept. 13	3,409,400	A few bright bodies.	Two pyriform bodies	do	20–30 per cent macrocytes, one punctate corpuscle.	101.8	84	42	September 11.—A few ticks just hatched placed on this animal to-day and a considerable number of adults removed.
Sept. 18	4,735,000	Very few bright bodies.	None	do	Macrocytes diminishing.	102.7	....	....	
Sept. 22	4,278,700	None	do	do	Macrocytes increased.	104.9	84	60	A large number of small ticks visible on animal.
Sept. 24	3,765,000	A very few pyriform bodies.	Same as in fresh preparation.			106.9	108	36	Urine highly colored; no hæmoglobin; barely alkaline; specific gravity 1020; slight quantity of albumen.
Sept. 27	1,639,000	Several motile bright bodies.	None	Crenated		105.5	....	....	
Oct. 4	3,305,100		do	Macrocytes	50 per cent macrocytes.	101.6	72	30	Large number of ticks now nearly matured.
Oct. 9	3,367,000	None	do	do	do	103.6	84	36	October 25.—Removed from stable.
Oct. 17	3,833,000	Two bright motile bodies.	do	do	Macrocytes diminishing.	102	84	36	
Nov. 8	5,220,000	None	do	do	About 10 per cent still present.	101.7	66	27	

No. 139 (native).—Cow, 6 years old, received August 30, 1890, from Prince George County, Md., and exposed in field II (Texas cattle with ticks).

September 11.—Temperature, 105.2; pulse, 84; respiration, 72. Red corpuscles 5,285,000. In fresh preparations of blood a comparatively large number of corpuscles contain bright motile points, perhaps 10 or more in each field. In stained preparations no abnormal elements detected.

September 13.—Cow dead this morning. Some animal heat still present in the body. Quite sick yesterday evening, but still on her feet.

Autopsy: Animal weighs about 700 pounds. A small number of quite small ticks attached to body. Blood from a subcutaneous vein was examined at 9:50 a. m. In fresh preparations a considerable number of corpuscles contain the bright bodies. A small number contain each one or two roundish pale bodies 1 to 2 μ in diameter.

In stained preparations about 10 per cent of the corpuscles are infected. The parasites are not all of the same age. Some are round bodies 0.7 to 0.8 μ in diameter, situated near or at the periphery of the corpuscle. Usually but one in a corpuscle. In a small percentage the parasites are in pairs, from 1 to 2 μ in diameter, slightly pear shaped and more centrally situated.

In blood from the heart the fresh preparations show numerous corpuscles containing the bright bodies as well as the larger pale parasites. The stained preparations do not differ from those obtained from the blood of the subcutaneous veins.

Lungs not fully collapsed. The small anterior lobes somewhat hyperæmic and emphysematous.

Heart shows more or less ecchymosis under epicardium of left ventricle, with petechiæ on the fat at the base. In both ventricles a small clot with some fluid blood. Extensive extravasation under endocardium of the left ventricle. One small area in the right. Myocardium normal.

Spleen weighs 4½ pounds; engorged, very friable. The pulp has a dark-red glistening appearance, obscuring Malpighian bodies entirely.

Liver weighs 16 pounds; enlarged, edges rounded. Much blood flows from the hepatic veins on section. In the larger ones are occluding thrombi 6–7^{mm} in diameter, some branched. They are mottled grayish and dark red and appear to be composed chiefly of blood plates. In teased preparations and fresh sections of liver tissue the bile injection is found generalized and the fatty degeneration coextensive with it. Occasionally minute red needle-like crystals observed. In sections of liver tissue (hardened in alcohol and embedded in chloroform paraffin) stained in hæmatoxylin, the trabecular arrangement of the parenchyma has largely disappeared. The cell protoplasm is finely vacuolated in some places. In others the vacuoles are quite large. There is more or less nuclear disintegration over the inner zones of the lobule. Cells with normal and partly degenerated nuclei and some without nuclei are intermingled.

In the gall bladder about one pint of bile, which holds in suspension an abundance of yellowish flocculi, but still flows readily.

Kidneys show intense congestion throughout. All capillaries gorged with blood. In tubules lumps of yellowish pigment. In sections of kidney tissue (hardened in Müller's fluid and embedded in chloroform paraffin) stained in hæmatoxylin, the parenchyma appears undisturbed by pathological changes. In all the capillaries of the glomeruli and the tubules which are distended with red corpuscles, the latter quite invariably contain each one or two parasites. Urine in bladder (2 to 3 quarts) has a deep port-wine color and is quite opaque. A faint light transmitted through a layer ¾ inch deep. Specific gravity 1027. Alkaline. Acetic acid gives an abundant flocculent precipitate. With Esbach test 2.1 per cent albumen present.

Digestive tract: Contents of third stomach dry and hard. Mucosa of fourth stomach is of a dark, bluish-pink color. Worm pits abundant. In the pyloric portion a considerable number of erosions with blackish base and puckered margins.

The mucosa of the small intestine hyperæmic and covered with a thin layer of mucus.

Cæcum contains soft feces. Mucosa hyperæmic. In the rectum considerable pigmentation along summits of longitudinal ridges. Feces soft.

In stained preparations the following approximate figures of infected corpuscles were obtained:

In blood from subcutis and right heart, 10 per cent; in spleen, 20 to 30 per cent; in liver, 20 to 30 per cent; in kidneys, 50 per cent; in addition a very large number of free parasites coming from disintegrated corpuscles. Perhaps one-half of the infected corpuscles contain each a pair of parasites. They are 1 to 2 μ in diameter. (For the temperature record, see pp. 274, 275, and 276.)

No. 140 (native).—Heifer, 2 years old, from Prince George County, Md. Received September 9, 1890, and placed in box stall on a neighboring farm on which Texas fever had never existed. The animal, therefore, has not been on the station grounds. Blood corpuscles, 6,047,000. In several preparations of fresh blood a small number (perhaps a dozen found in a preparation after a little searching) of bright bodies observed within corpuscles, some in motion.

Several thousand young ticks, hatched three to four days ago, were placed on the thighs, udder, and flank of this heifer, which was thrown for this purpose. (See also No. 137.)

September 22.—Temperature, 105.5; pulse and respiration, 96. Corpuscles, 5,790,000. The number of bright intraglobular bodies increased. Several small parasites observed within corpuscles in dried and stained preparations. Animal well covered with young ticks the size of hemp seeds.

September 27.—Temperature, 104.4; pulse, 84; respiration, 96. Corpuscles, 2,800,000. Tend to crenate and shrivel. Bright bodies diminished in number. No parasites detected. The urine examined to-day is normal. The amount of carbonates diminished.

September 30.—Temperature, 102.5; pulse, 96; respiration, 78. Corpuscles, 2,628,500. A considerable number of macrocytes now present. In general the corpuscles show a tendency to crenate. In fresh preparations a moderate number of intraglobular, rather large, paired parasites are detected. In stained preparations about ½ to 1 per cent of the corpuscles are infected with large parasites. There are also about 2 per cent of the cells punctate, and a smaller number are diffusely stained. Brought to experiment station to-day and placed in a stall in the barn.

October 2.—Found dead in her stall, with head drawn back and to one side. Considerable heat still in body.

Autopsy at 10 a. m.: Animal more or less wasted by the disease; weighs about 500 pounds. On thighs, udder, neck, and shoulders a large number of ticks, some full-grown and ready to drop off; others just completing the last molt.

Lungs retain expanded form when thorax is opened. One of smaller lobes on the right slightly hyperæmic. In both bronchi are firm, dark blood clots, extending into branches. There is no blood in the mouth or upper air passages nor in the œsophagus. The source of the blood not discoverable.

Heart: Ecchymoses on the left ventricle, with marked injection of the smallest vessels visible to the naked eye. The right heart contains a firm, dark clot extending through auricle into large veins. Left contains a small clot, quite firmly contracted. Fatty degeneration of fibers pronounced.

Spleen weighs 3½ pounds. Parenchyma soft and yielding; congested. Malpighian bodies prominent. Very little pigment observed in teased preparations.

Liver weighs about 11 pounds. More or less enlarged. Parenchyma of a pale brownish-red color; texture still firm. In the hepatic veins a considerable quantity of fluid blood. In sections of fresh tissue the bile injection appears only in small patches, accompanied by extensive fatty changes. In the remainder of the parenchyma the hepatic cells contain much pigment in the form of granules barely visible at 500 diameters.

About 400 cubic centimeters of very thick, turbid bile in the gall bladder, holding a large quantity of yellowish flocculi in suspension.

The kidneys are very pale throughout, and quite flabby to the touch. In fresh sections no marked changes in the epithelium observed.

The bladder contains ¾ liter of light claret-colored urine. Faintly alkaline; specific gravity, 1012. Slight flocculent precipitate after boiling.

Digestive tract: Contents of third stomach somewhat firm. In fourth stomach from 1 to 2 liters of a turbid liquid. Mucosa quite pale and free from anatomical changes. In duodenum, bile-staining marked. Occasional patches of vascular injection. In the walls of the ileum worm tubercles. The mucosa normal. Soft feces present.

In the cæcum a large quantity of soft feces; colon and rectum empty. Mucosa throughout unaffected.

In the various organs infected corpuscles are present, but in small numbers. The parasites are roundish, about 1.5 μ in diameter. Fully one-half of the infected corpuscles contain two, the rest one parasite. Their distribution is as follows: Heart's blood very few; spleen 2 to 3 per cent; liver and kidneys 5 to 10 per cent. (For temperature record, see p. 283.)

No. 142 (*native*).—Heifer, 1 year old when received, September 16, 1890, from Prince George County, Md.

Blood was taken on this day from heart of No. 90 about one-half hour after death. This was beaten in a sterile bottle with sterile glass rods and kept at 35° to 40° C. in a warm chamber from 2 to 3:30 p. m.

The left external jugular vein of No. 142 was exposed by making an incision through the skin 1¼ inches long. The needle of a syringe was made to puncture the wall of the vein made tense at the root of the neck by pressure, and 7 cubic centimeters of blood injected slowly. Three stitches were used to bring together the edges of the skin incision. The animal was placed in the same inclosure with No. 111 (field I) and a healthy control animal, No. 143, from the same source, was placed with it. The wound healed quickly and normally. The following table gives the result of the examinations of the blood. The complete temperature record may be found on page 275:

No. 142 (*native*).

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.	
1890						
Sept. 16	6, 890, 000					102. 2
Sept. 22	5, 430, 000	None	None	Normal	Normal	100. 8
Sept. 24	4, 562, 500		Two doubtful forms	....do	A few macrocytes	101. 8
Sept. 29	5, 274 500	None	None	....do	Normal	102. 6
Oct. 4	3, 902, 400		Several parasites of irregular form.	....do	....do	100. 2
Oct. 8	5, 983, 606	None	None	A few macrocytes.	A few macrocytes	102. 5
Oct. 22	4, 333, 000	...do	....do	....do	....do	101. 8
Nov. 4	5, 586, 000	...do	....do	....do	....do	102

No. 143 (native).

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature record, see pp. 275, 284, and 286.)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
Sept. 29, 1890	6,261,900	None	None	Normal	Normal	101.3	60	24	Heifer, 18 months old, received September 16, from Prince George County, Md., and placed in field I as a control animal with inoculated animal No. 142.
Oct. 8, 1890	6,835,000	do	do	do	do	102.4	54	24	October 27.—Transferred to stable artificially heated.
Oct. 25, 1890	6,500,000	Several bright bodies	do	Shriveled	do	103	48	22	October 23.—Several hundred young ticks which had been hatching since October 24, placed on udder, flank, and neck. These ticks hatched from eggs laid by ticks raised on No. 138. The adults had been picked from No. 138 on September 11.
Nov. 1, 1890	7,000,000	One bright body	do	Normal	do	102.3	56	36	
Nov. 4, 1890	6,965,000	None	do	do	do	102	63	32	
Nov. 8, 1890	6,058,000	do	do	Crenated	do	102.8	63	40	A second lot of young ticks (200–300) placed on this animal.
Nov. 10, 1890	5,737,000	do	do		do	104.3	60	90	
Nov. 11, 1890	5,578,000	Two bright bodies	do		do	103.2	66	42	
Nov. 13, 1890	5,318,000	One bright body	do	Crenated	do	104	70	66	
Nov. 17, 1890	5,175,000	None	do	do	do	103.6	72	56	
Nov. 21, 1890	5,471,000	One bright body	One doubtful form	do	do	105	80	72	
Nov. 26, 1890	5,190,000	None	do	do	Shriveled in part	104	64	76	
Dec. 2, 1890	5,333,000	do	do	do	Normal	102.8	60	48	December 12.—Animal less thrifty and thinner than when placed in stable. Removed to-day.
Dec. 8, 1890	5,644,000	do	do	do	do	102.9	64	52	
Aug. 24, 1891	2,870,900	A few large parasites, a few bright bodies.	do	do	Some macrocytes	107	51	90	July 2, 1891. Reëxposed to Texas fever in field VI. (North Carolina cattle with ticks.)
Aug. 27, 1891	3,650,000	None	do	Some macrocytes	Some tinted and punctated corpuscles.	102.6	52	72	From August 13 rapid falling away in flesh. On August 26 quite thin and weak. Improvement began September 1 and continued through the fall. On October 23 she was again in fair condition.
Sept. 1, 1891	3,436,000	do	do	Many macrocytes	30–50 per cent macrocytes.	107(?)	78	84	
Sept. 2, 1891		do		do					
Sept. 4, 1891	2,984,000	do		do	25–30 per cent macrocytes.	102.6	60	60	
Sept. 12, 1891	3,515,600 (white 9,376)	do	None	do	do	101.8	48	30	
Oct. 13, 1891	4,700,000	do	do	Some macrocytes	Some macrocytes	102.2	84	30	

No. 144 (*native*).—Cow, 8 years old, received September 17, 1890, from Maryland, and placed in wooded Field X (Fig. 6, p. 102). On this day a considerable number of ticks hatched in the laboratory were placed on this animal. The hatching began September 4 and continued several days. (See also Nos. 137 and 140, to which ticks from the same lot were applied.)

September 18, 11:30 a. m.—Temperature, 101.2. Red corpuscles, 6,299,000; normal. In fresh blood a few corpuscles contain bright motile bodies. Nothing detected in stained preparations.

September 25.—A second lot of young ticks placed on this animal.

September 29.—Temperature, 106.2; pulse, 54; respiration, 27. Red corpuscles, 4,934,000. In fresh preparations a few corpuscles contain bright motile bodies. In one corpuscle a large parasite. In stained preparations about one infected corpuscle in every two or three fields. The contained parasite is irregularly roundish and about 1 μ in diameter. A large number of small ticks visible between thighs and on escutcheon.

October 3.—Cow found dead this morning; seen alive yesterday at 5 p. m.

Autopsy notes.—Body in fairly good condition, weighing about 550 pounds. A large number of ticks on the inside of the thighs down to hocks, on the escutcheon, and udder; a few on neck, shoulders, and in the axilla.

Heart.—A considerable number of punctiform hemorrhages under the epicardium of both ventricles. In the right ventricle a small dark clot and some fluid blood. In the left, which is quite firmly contracted, a little clotted blood. Much extravasation under the endocardium of this ventricle; especially marked on the papillary muscles.

In blood from the heart examined fresh a small number of corpuscles contain motile and nonmotile bright bodies. Several contain the large stage of the Texas-fever parasite. Examination made unsatisfactory, owing to post-mortem shriveling and distortion of the red corpuscles.

Lungs only partially collapsed, slightly congested, and œdematous. Trachea and bronchi coated with fine froth; mucosa of trachea reddened.

Spleen weighs 4½ pounds. Under the capsule several large patches of extravasation. Pulp very soft, dark. Usual markings no longer visible on section. Very little pigment detected under microscope.

Liver weighs about 12½ pounds. Pale yellowish brown. On section, the yellowish color very marked. The cut ends of the hepatic vessels discharge thick blood. On the various surfaces are seen irregular yellow spots about ½ inch in diameter, which correspond to yellow foci extending into the liver tissue for ¼ to ½ inch. In fresh sections under the microscope about ⅘ of each lobule has its bile capillaries distended with bile, accompanied by extensive fatty degeneration. The yellow spots above mentioned represent masses of tissue completely degenerated. Numerous microscopic blood-red needle-like crystals in the fresh tissue. (Plate III, Fig. 2.)

In the gall bladder the bile is very thick with solids and mucus, so that it scarcely flows when poured.

Kidneys uniformly and deeply congested. In the convoluted tubes of cortex a large quantity of fine yellowish pigment may be seen in fresh sections. In the bladder over three pints of urine, having a deep port-wine color. It is barely translucent in a ⅝-inch test tube. Feebly alkaline. Specific gravity, 1015. Heavy flocculent precipitate, with acetic acid in the cold. About 0.6 per cent albumen present.

In the various organs and tissues examined stained, the intraglobular parasites appear as round coccus-like bodies, either one or two in a corpuscle from 1 to 1.5 μ in diameter. The infected corpuscles are scarce in blood from heart; in the spleen there are about 2 per cent. They are slightly more abundant in the liver. In the kidney there are from 20 to 30 per cent. Besides these parasites there are present large post-mortem bacilli, in small numbers in the blood and spleen, abundant in liver and kidney. (For temperature record, see p. 283.)

No. 145 (native).

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature record, see pp. 283, 284, and 285.)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
Sept. 18, 1890	6,983,000	Some bright motile bodies.	None	Normal	Normal	102	....	....	Heifer, 18 months old, received September 17, 1890, from Prince George County, Md. Placed in box stall on station and fed once daily with ¼ bushel grass cut from infected field VI, together with hay and mill feed until October 12
Oct. 6, 1890	6,308,600	Considerable number of bright bodies.	....do	....do	....do	101.4	60	24	
Oct. 17, 1890	6,538,400	Spoiled	....do	....do	....do	101.9	72	24	
Nov. 4, 1890	6,661,000	Very few bright bodies	....do	....do	....do	102	66	24	
Nov. 13, 1890	5,380,900	2–3 per cent bright bodies.	....do	....do	....do	101.6	60	40	Placed in artificially heated stable October 27, as control to Nos. 143 and 149.
Nov. 17, 1890	5,682,000	......do	....do	....do	....do	101.7	64	48	
Nov. 24, 1890	6,061,000	4–5 per cent bright bodies.	....do	....do	....do	101.5	68	58	November 21.—Condition up to date good as before confinement. From 100 to 200 young ticks placed on this animal. An equal number applied on each of the following days: November 23, 25, 27, 29, December 1 and 3. These young ticks were hatched from eggs laid by adults which were picked from Nos. 137, 138, and 140.
Nov. 28, 1890	5,965,000	Few bright bodies	....do	....do	....do	100.8	52	40	
Dec. 5, 1890	5,437,000	......do	....do	....do	....do	104.1	68	80	
Dec. 8, 1890	6,129,000	Several pairs of pyriform bodies.	Several pairs of pyriform bodies.	....do	....do	100.4	64	44	
Dec. 11, 1890	5,530,000	A few bright bodies	None	....do	....do	100.8	68	24	
Dec. 15, 1890	4,965,000	......do	....do	....do	....do	101.8	64	36	December 14.—First full-grown ticks collected.
Dec. 22, 1890	5,578,000	......do	....do	....do	....do	101.5	64	36	January 3, 1892.—Last full-grown ticks collected to-day. Only 75 matured in all.
Dec. 27, 1890	5,069,000	......do	....do	....do	....do	101.6	72	52	
Jan. 16, 1891	4,379,000	......do	15–20 per cent peripheral cocci.	....do	....do	101.5	72	56	
Jan. 20, 1891	3,075,000	......do	....do			103	104	64	

No. 145 (native)—Coutinued.

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks.
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
Jan. 22, 1891	3,000,000	....	....do	Many macrocytes...	5–10 per cent punctated corpuscles; 1 per cent diffusely stained.	104.4	92	72	Jan. 23.—Animal has partially lost appetite for three or four days past, and to-day refuses food entirely.
Jan. 24, 1891	1,918,000	....	....do	Many macrocytes, a few hæmatoblasts	Punctated and tinted corpuscles increased.	104	108	48	
Jan. 27, 1891	1,250,000	Doubtful	10 per cent. peripheral cocci.	Many macrocytes, 5 per cent hæmatoblasts.	20 per cent punctated and tinted corpuscles.	104	104	40	January 27.—Animal begins to eat a little. Very thin and weak.
Jan. 29, 1891	1,263,000	None	5 per cent peripheral cocci.	....do	Many punctated and tinted corpuscles.	103.8	88	68	
Jan. 31, 1891	1,451,400	A few bright bodies ..	....do	Hæmatoblasts fewer many macrocytes.	....do	102.4	84	40	
Feb. 5, 1891	2,363,000	......do	Peripheral cocci rare.	Nearly all corpuscles enlarged; a few hæmatoblasts.	1–2 per cent punctated and tinted corpuscles.	102.4	80	36	
Feb. 9, 1891	2,681,000	......do	2–3 per cent peripheral cocci.	Many macrocytes...	A few punctated and tinted corpuscles.	102	84	44	
Feb. 12, 1891	3,100,000	....	1–2 percent peripheral cocci.	....do	Punctated cells scarce.	101.4	76	40	
Feb. 18, 1891	3,277,000	....	½–1 per cent peripheral cocci.	....do	....do	101.7	76	48	
Feb. 26, 1891	3,689,000	A few bright bodies ..	None	A few macrocytes ..	Normal	101.2	72	52	
Mar. 10, 1891	4,259,000	None	....do	Macrocytes rare....	....do	102.1	80	36	
Mar. 18, 1891	5,316,000	......do	....do	Normal	....do	102	80	32	
Apr. 1, 1891	5,083,000	One bright body......	....do	....do	....do	103	80	24	Improvement gradual since January 27. Now in good condition and fully recovered. Removed from stable.
Apr. 13, 1891	5,354,000	None	....do	....do	....do	102.4	80	22	June 9.—Gives birth to a healthy calf.

No. 149 (native).

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature record, see p. 284.)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
Oct. 28, 1890	7, 253, 700	One bright body	Negative	Normal	Normal	102.5	60	48	Heifer, 18 months old, received October 25, 1890, from Prince George County, Md. October 27.—Placed in artificially heated stable. October 28.—About 15 young ticks applied. (For source see No. 143.)
Nov. 3, 1890	6, 222, 000	Negative	do	do	do	102.6	60	48	A similar number applied October 30, November 2, 7, 12, 16, and 21.
Nov. 6, 1890	6, 295, 000	do	do	do	do	102.5	54	42	
Nov. 11, 1890	5, 737, 000	do	do	do	do	102.4	54	54	
Nov. 15, 1890	5, 683, 000	One bright body	do	Crenated	do	103.4	57	54	
Nov. 19, 1890	6, 120, 600	Negative	do	Normal	do	102.8	56	80	
Nov. 28, 1890	5, 705, 000	do	do	do	do	102	66	72	
Dec. 8, 1890	6, 321, 000	do	do	do	do	101	56	48	December 12.—Exposure negative. Removed from stable.
Oct. 2. 1891	6, 340, 000 (white 9, 434)	One bright body	do	do	do	103.2	90	54	Not exposed this season.

No. 152 (native).

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature record see p. 285.)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
Dec. 11, 1890	5,981.000	Moderate number of bright bodies, some motile.	Negative	Normal	Normal	102.2	60	32	Cow, 4½ years old. Received December 10, 1890, from the District of Columbia. December 12.—Placed in artificially heated stable. December 13.—About 200 young ticks placed on neck and rump.
Dec. 22, 1890	7,018,900	do	do	do	do	102.4	56	52	These hatched from eggs laid by North Carolina adults in the laboratory. A similar number applied December 15, 17, 19, 21, 23, 25, 27, and 29.
Dec. 26, 1890		do	do						
Dec. 27, 1890	7,612,900	Small number of bright bodies.	do	Normal	Normal	102.5	60	56	
Dec. 30, 1890	6,888,800	5–10 per cent bright bodies, many motile.	Several large parasites.	do	do	105.2	56	72	
Jan. 2, 1891	5,600,000	Fewer bright bodies, many motile.	3 pairs of large parasites.	do	do	102.0	56	70	From December 31 to January 2, partial loss of appetite and slight loss of flesh. From January 3 to 17, appetite returned, but condition still somewhat below normal.
Jan. 6, 1891	5,314,000	A few bright bodies, many motile.	Several large parasites.	do	do	102.2	56	72	
Jan. 9, 1891	4,242,400	3–4 per cent bright bodies, many motile.	One large parasite.	do	One hæmatoblast.	101.6	64	60	
Jan. 16, 1891	4,460,000	Several bright bodies many motile.	Negative	More or less variation in size.		102.0	52	68	
Jan. 20, 1891	5,126,000	do	do	do	One hæmatoblast.	102.4	60	56	
Jan. 24, 1891	5,073,000	Negative	do	do	do	101.6	60	52	
Jan. 29, 1891	5,468,000	One bright body	do	Normal	Normal	101.3	60	40	
Feb. 5, 1891	6,080,000	Two bright bodies	do	do		101.7	56	36	January 31.—Entirely recovered.
Feb. 18, 1891	2,370,000					101.8	52	56	
Feb. 26, 1891	6.569.000	Small number of bright motile bodies.	Negative			101.2	48	24	
Mar. 10, 1891	6,359,000	One bright body	do			101.4	48	32	
Mar. 18, 1891	6,222,200	Several bright bodies.	do			101.2	52	24	
Apr. 1, 1891	6,754,000	Two bright bodies	do			101.8	56	24	April 11.—Removed from stable.
Apr. 13, 1891	6,894,000	Moderate body	do			100.2	42	18	
Oct. 3, 1891	5,200,000 (white 10,909)	Negative	do			100.8	60	60	

No. 154 (*native*).—Heifer, 1 year old, received March 16, 1891, from the District of Columbia. In May, placed in wooded field No. X, with several North Carolina cattle of 1889 and 1890. (The disease was induced in this animal by ticks which wintered over from the fall of 1890.)

September 1, 1891.—Temperature, 103.7; pulse, 132 (due to chasing); respiration, 54. The animal to-day is thin and weak. A considerable number of ticks of various stages on the thighs and udder. Condition of the blood: Red corpuscles 2,075,400. In the fresh preparation of blood from skin probably 20 per cent of the corpuscles are enlarged (macrocytes). One intraglobular bright body and one hæmatoblast detected in one fresh preparation. In several stained preparations a large percentage of the macrocytes are either uniformly tinted or else punctated. After a long search, several large pyriform parasites detected within corpuscles.

September 7.—Temperature, 103.2; pulse, 96; respiration, 52. Red corpuscles, 3,433,300; white corpuscles, 10,000. Fully 30 per cent are larger than normal. Tinted and punctated forms have disappeared.

October 6.—A few large ticks on animal. Temperature, 100; pulse, 85; respiration, 42. Red corpuscles, 4,161,800; white, 10,909. A considerable number are macrocytes. In stained preparations nothing abnormal besides the variation in size.

November 4.—Temperature, 100.6; pulse, 72; respiration, 24. Red corpuscles, 6,984,000; white corpuscles, 18,781. Nothing abnormal in stained and fresh preparations.

No. 158 (native).

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks.
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
July 29, 1891	5, 254, 000	A few bright bodies.	Negative	Normal	Normal	102	66	48	Steer, 2 years old, received April 3, 1891, from Montgomery Co., Md. Placed in field I. To-day, several thousand young ticks placed on rump and neck. These young ticks were hatched July 23 and 24 from eggs collected July 7. The adults from which they were obtained were taken from cattle near New Berne, N. C., June 25-27. Egg laying began June 29, and continued to July 7.
Aug. 3, 1891	4, 613, 300	....do	....do	....do	....do	101.7	60	60	
Aug. 6, 1891	4, 794, 000	More bright bodies	....do	....do	....do	105.4	72	96	
Aug. 10, 1891	3, 169, 000	Negative	Several large parasites.	....do	....do	107.2	96	132	August 8.—General gaunt appearance. Has become quite weak and thin. Losing flesh rapidly.
Aug. 14, 1891	2, 434, 400	A few parasites of irregular form.	A few large parasites.	A few macrocytes.	A few tinted cells	105.8	96	114	
Aug. 17, 1891	2, 370, 000	A few large parasites.		About 30 per cent macrocytes.	Many tinted and punctate cells.	103.2	60	90	August 19.—Has continued the same to date. Thirty adult ticks collected to-day.
Aug. 22, 1891	1, 500, 000	....do		About 30–40 per cent macrocytes.	....do A few hæmatoblasts	104	88	92	
Aug. 26, 1891	1, 958, 300	....do		Fifty per cent	Many tinted and punctate cells.	103.4	66	90	Ticks have nearly all matured. Since August 19 from thirty to fifty matured ticks removed each day.
Sept. 5, 1891	1, 670, 600 (white 10,545)	Negative	Negative	A few macrocytes.	Very few stained forms.	102.2	56	48	
Sept. 15, 1891	2, 694, 900 (white 13,569)	....do	....do	Normal	Normal	101.2	52	42	September 30.—Improvement has been very slight since August 19.
Oct. 7, 1891	3, 369, 000 (white 15, 789)	....do	....do	Some macrocytes	Some macrocytes	101.2	66	15	October 17.—Appetite has returned. Animal still thin.
Oct. 21, 1891	3, 609, 000	....do	....do	Normal	Normal	102.8	64	52	Ticks on animal. These are the progeny of those which matured and dropped upon the ground in August.
Nov. 10, 1891	4, 328, 500 (white 8,571)	....do	....do	....do	....do	102	78	24	Ticks on animal (about 75 in all). December 21.—Slow improvement since October 17. General condition fair.

No. 159 (native).

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature record see p. 286.)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
May 25, 1891	5, 871, 400	Some bright bodies	None	Normal	Normal	101.5	92	24	Heifer, 2 years old. Received April 3, 1891, from Montgomery Co., Md. July 2.—Exposed in field VI. (North Carolina cattle with ticks.)
Aug. 13, 1891	5, 949, 000	....do	....do	....do	....do	102.7	66	54	
Aug. 24, 1891	4, 646, 000	2-3 per cent bright bodies.	One pair large parasites.	....do	....do	106.9	105	72	
Aug. 25, 1891	4, 187, 000	Some bright bodies	A few irregular forms.	....do	....do	105.8	108	54	
Aug. 29, 1891	3, 338. 000	Spoilt	Negative	....do	....do	102.6	72	52	September 1.—Has lost but little flesh during the mild attack.
Sept. 7, 1891	4, 339, 000 (white 11, 320)		One pair large parasites.	Some macrocytes	Some punctate cells	101.8	60	42	Many ticks of all stages on animal.
Oct. 6, 1891	4. 872, 700 (white 9, 090)	None	None	....do	Some macrocytes	101.8	96	30	A few small ticks on animal.
Nov. 7, 1891	4, 650, 000 (white 8, 833)		....do	....do	Some punctate and tinted cells.	101.4	72	38	October 23.—Has regained her former condition. Animal has probably had a second attack or relapse since last examination. December 21.—General condition good.

No. 160 (native.)

Date.	Number of red corpuscles.	Parasites in red corpuscles. In fresh preparations.	Parasites in red corpuscles. Dried and stained.	Condition of red corpuscles. In fresh preparations.	Condition of red corpuscles. Dried and stained.	Temperature.	Pulse.	Respiration.	Remarks. (For temperature record see p. 286.)
Sept. 21, 1891	5, 301, 800 (white 7, 358)	Some bright bodies	None	Normal	Normal	102	90	56	Heifer, 2 years old. Received April 3, 1891, from Montgomery Co., Md.
Oct. 1, 1891	5, 762, 700 (white 13, 559)	One bright body	do	do	do	101. 6	84	72	September 21.—Placed in field VI (North Carolina cattle with ticks) with her calf, No. 178.
Oct. 7, 1891	3, 645, 100 (white 9, 677)	Some bright bodies	1–2 per cent large parasites.	do	do	106. 2	112	36	
Oct. 9, 1891	2, 911, 700 (white 10, 294)	None	Several large parasites.	do	Some punctate cells.	106. 4	100	44	
Oct. 27, 1891	3, 861, 500	do	None	Many macrocytes.	Many macrocytes	101. 4	100	44	
Nov. 7, 1891	2, 128, 000 (white 8, 974)		Nearly 50 per cent of peripheral bodies (Pl. IV, Fig. 3.)	do	Some punctate cells.	103. 4	96	48	
Nov. 12, 1891	1, 351, 500 (white 14. 062)	Some bright bodies	A few peripheral bodies.	do	Many tinted and punctate cells, (Pl. IX, Figs. 5, 6).	102. 4	104	48	
Nov. 14. 1891	1, 812, 500 (white 14, 583)		None	do	Many tinted and punctate cells.	101. 5	84	30	No ticks detected.
Nov. 21, 1891	2, 912, 281 (white 8, 772)		5 per cent peripheral bodies.	do	No tinted and punctate cells.		84	36	
Dec. 6, 1891	2, 716, 600 (white 13, 333)		5-10 per cent of peripheral bodies.	do	A few tinted and punctate cells.	102. 4	88	36	December 21.—Animal still thin.
Aug. 26, 1892	6, 157, 000 (white 10, 000)		None		Normal	101	84	48	Reëxposed to-day in field VI (North Carolina cattle with ticks).
Sept. 12, 1892	5, 268, 000 (white 12, 195)	2–3 per cent bright bodies.	do	Normal	do	102	78	36	
Sept. 21, 1892	5, 390, 000 (white 19, 736)		do		do	101. 5	80	32	October 1.—Exposure negative. Condition of animal unchanged.

No. 161 (native). For temperature record see page 287.

Date.	Number of red corpuscles.	Parasites in red corpuscles. In fresh preparations.	Parasites in red corpuscles. Dried and stained.	Condition of red corpuscles. In fresh preparations.	Condition of red corpuscles. Dried and stained.	Temperature.	Pulse.	Respiration.	Remarks.
May 20, 1891	5, 986, 400	Some bright bodies	None	Normal	Normal				Cow, 6 years old. Received May 7, 1891, from Maryland.
Aug. 27, 1891	5, 394, 000	None	do	do	do	101. 9	78	60	July 2.—Placed in field XI (North Carolina cattle without ticks).
Aug. 31, 1891	4, 910, 700		do	do	do	101. 8	60	48	August 21.—Several young ticks found on animal.
Sept. 7, 1891	5, 380, 000 (white 12, 000)	do	do	do	do	101. 4	68	36	September 3.—A few ticks picked off daily, as found, since August 2.
Oct. 15, 1891	4, 685, 000	A few bright bodies	do	do	do	102. 5	60	20	October 5.—Ticks removed every other day, as found, since September 3.

No. 162 (*native*).—Cow, age 6 years; received September 1, 1891, from Maryland. Placed in uninfected field XII.

September 26.—Animal first observed dull and refusing to eat.

September 28.—Temperature above 104° F. The animal is very weak, disinclined to move, and remains in shed. Feces passed in small quantities at short intervals; stained yellow and quite liquid.

September 29.—Found dead this morning.

Autopsy: Body fairly well nourished; weighs about 650 pounds. No ticks observed, though very carefully looked for.

In abdomen the omentum shows injected patches. Under the serosa of fourth stomach a patch of extravasated blood 10 inches long and 2½ to 3 inches wide.

In thorax, lungs somewhat œdematous. In both ventricles of heart considerable fluid blood and a small clot. Capillaries of heart muscle gorged with red corpuscles. Fatty degeneration of fibers.

Spleen weighs 4 pounds. Pulp blackish, softened. Usual markings on section no longer visible.

Liver weighs about 16 pounds. On surface and on section the tissue has a diffuse yellowish hue. Fatty degeneration and bile injection as yet slight. In the gall bladder about 6 ounces of yellowish green bile, holding an abundance of flakes in suspension.

Kidneys uniformly congested throughout. All capillaries choked with red corpuscles. In the bladder about 1 quart of urine, having a deep port-wine color. Specific gravity, 1022; reaction, neutral. Abundant precipitate, with acetic acid in the cold. Esbach's test gives 3 per cent albumen. In uterus a fœtus about 6 months old.

Stained cover-glass preparations from the blood and tissues show an extensive infection of red corpuscles with Texas-fever parasites. The parasites are mainly roundish, either single or in pairs, and not yet full grown. Their approximate numbers may be given as follows:

	Per cent.
Blood from subcutaneous vein, about	5
Blood from heart, about	5
Blood from marrow of rib, about	5
Spleen	10
Liver tissue	40–50
Kidneys	70–80
Heart muscle (capillary blood)	30

No. 163 (*native*).—Cow, 6 years old, received May 7, 1891, from Maryland.

July 2.—Placed in field VI (North Carolina cattle with ticks).

August 13.—Temperature, 102.3; pulse, 54; respiration, 48. Red corpuscles, 5,000,000. A small number of corpuscles contain bright bodies. Stained preparations negative.

August 24.—Temperature, 106.8; pulse, 66; respiration, 57. Corpuscles, 3,388,800. In fresh preparations a moderate number of corpuscles containing bright bodies. They vary in size from barely visible points to $\frac{1}{2}\,\mu$ in diameter ($\times$ 680). The smallest are most active, although all sizes are observed to change their place within the corpuscles. In stained preparations a very few corpuscles contain each a pear-shaped parasite.

August 25.—Animal is dull, quite weak, and losing flesh rapidly. Temperature, 107; pulse, 80; respiration, 24. Corpuscles, 2,645,000. The blood from the skin, examined fresh, contains corpuscles with bright bodies and some which contain the pale, pear-shaped parasites. Those containing the latter have a degenerated appearance. Amœboid changes detected on the warm stage.

Killed by a blow on the head at 11.45 a. m., and the autopsy made immediately.

Weight of animal about 500 pounds. A large number of ticks on the escutcheon and inner surface of thighs; they are especially abundant on the escutcheon, where

they are crowded close together over an area 6 inches long by 2 inches wide; on the abdomen and thighs they average about 4 to the square inch. A considerable number are attached to the neck, in front, from the larynx to the sternum.

In abdomen the omentum over the paunch shows numerous hyperæmic patches.

Heart and lungs normal. Strongyli in the bronchi.

Spleen weighs 2⅝ pounds; engorged with blood-corpuscles as shown on the cut surface, which has a blackberry-jam color. Trabeculæ and Malpighian bodies barely visible. Several specimens of an unknown filaria in the connective tissue between spleen and paunch. In the pulp, examined fresh, a little pigment in irregular lumps. Liver weighs 14 pounds; it appears slightly enlarged and paler than in the normal condition, both on surface and on section. In fresh sections the intralobular capillaries are found filled with corpuscles, the cells somewhat clouded and containing very minute pigment particles. Bile injection and fatty degeneration absent. The bile, although darker than in health, contains no flocculent matter. The mucosa of the fourth stomach quite uniformly reddened throughout; it is beset with paler spots from 2 to 8 to a square inch (probably the places where *Strongylus Ostertagi* is encysted). *Strongylus contortus* abundant. The villi of the small intestine are injected, the injection diminishing in intensity from above downward. Mucosa of cæcum pigmented along the summits of the longitudinal folds. Colon and rectum normal.

Kidneys uniformly and intensely congested. Capillaries distended with red corpuscles. The urine in bladder of a dark port-wine color. Specific gravity, 1,020. Alkaline. An abundant brownish precipitate when acetic acid is added. With Esbach's test, 0.3 per cent albumen.

A large number of dried and stained preparations from blood and the tissues of various organs were examined to determine the relative abundance of the infected corpuscles. The parasites were, as a rule, in pairs within the corpuscles, each containing one, very rarely two pairs. In form they were quite invariably pear-shaped. A few were roundish, and of these there was but one in a corpuscle. The relative distribution is approximately as follows:

Marrow of rib, very few infected corpuscles.

Skeletal muscles, very few infected corpuscles.

Blood from skin, very few infected corpuscles.

Blood from left heart, 2 to 3 per cent; blood from right heart fewer than in preceding; blood from lung tissue, 2 to 3 per cent; spleen pulp, 5 per cent; liver tissue, 10 to 20 per cent; kidney tissue, 10 to 20 per cent; hyperæmic spots on omentum, 50 per cent; heart muscle, 50 per cent and many free forms.

At the autopsy many fresh preparations from the various regions of the body were likewise scrutinized. In addition to the pear-shaped pairs within corpuscles the minute bright bodies were always detected. (For temperature record, see p. 286.)

No. 164 (*native*).—Cow, 7 years old, received May 7, 1891, from Maryland.

July 2.—Placed in field XI (North Carolina cattle without ticks).

August 26.—Temperature, 106.4; pulse, 93; respiration, 100. Corpuscles 4,142,800. In fresh preparation, a few bright motile intraglobular bodies. No large parasites seen. In stained preparations, after a long search, two intraglobular forms of irregular outline seen.

August 31.—Temperature, 102; pulse, 64; respiration, 44. A large number of small ticks on animal. Skin practically bloodless, so that many incisions were made before a drop of blood could be obtained. Red corpuscles, 1,661,000. Both fresh and stained preparations negative as regards parasites. Animal quite sick.

September 2.—Animal very weak, lying down and unable to rise. Has lost flesh rapidly within the past four days. Feces bile-stained. Temperature, 98; pulse, 78; respiration, 20. In two fresh preparations only three infected corpuscles detected after a long search. There are present about 10 per cent of macrocytes, some fully

twice the diameter of normal red corpuscles. When stained a few tinted corpuscles and some hæmatoblasts detected.

September 3.—Found dead early this morning.

Autopsy, 9 a.m.: A few ticks on thighs and udder. Rather strong odor of decomposition when abdomen opened.

Thorax. Heart appears pale and flabby. In both sides large, dark soft clots. Cloudy swelling of muscular tissue. Lungs œdematous. Interlobular emphysema in right principal lobe.

Abdomen. Spleen weighs 4 pounds. Very soft and flabby. Pulp diffluent. Considerable amount of pigment in lumps and granules.

Liver weighs 15½ pounds. Enlarged and flabby to the touch. Color markedly pale yellowish, with occasional spots of deeper yellow sprinkled throughout parenchyma. On closer inspection, the yellowish color is limited to the inner zones of the acini. The cut surface has thus a mottled appearance. In fresh sections much fatty degeneration of the hepatic cells, many of which contains lumps of pigment. Very little bile injection.

Gall bladder contains over a pint of very thick, viscid bile, holding in suspension a large amount of flocculent matter.

Kidneys pale and flabby. Pelvis ecchymosed. No distinct pathological changes observed in fresh sections. Very little pigment in the epithelium. Bladder empty.

Paunch nearly empty. Contents of third stomach more or less dry, impacted.

Microscopic examination of dried and stained cover-glass preparations gave the following result:

Blood from the heart contained large post-mortem bacilli, but no parasites. Blood from the subcutis equally negative.

In the spleen no parasites but bacilli present. In the kidney and liver very few blood corpuscles; many bacilli but no parasites.

In the uterus a fœtus 7 months old was found. Skin stained bright yellow over the entire body. In blood from the heart and in spleen pulp no parasites were detected. (For temperature record, see p. 287.)

No. 165 (*native*).—Heifer, two and one-half years old; received June 22, 1891, from Maryland. On August 29 it received into the right jugular vein ten cubic centimeters of fluid made by crushing ticks one and one-half months old in sterile water and passing the fluid through a Pasteur filter. (See also No. 183.) Up to October 20 no signs of disease could be discovered, as is shown by the following table of the blood examination. The temperature record will be found on page 287.

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.			
1891.								
July 25	5,233,700	Some bright bodies.	Negative .	Normal.....	Normal..	103.4	72	72
Aug. 29	5,854,000	One bright body....	....do	....do	..do	101.0	54	36
Sept. 5	5,545,000 (white 12,727)		....do		..do	101.0	78	42
Sept. 10	5,673,000 (white 9,615)	One bright body....	....do	Normal.....	..do	101.6	68	48
Sept. 18	5,384,600 (white 15,384)		....do		..do	102.6	84	54
Oct. 15	5,188,400	One bright body....	....do	Normal.....	..do	101.5	72	36

No. 166 (native).

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks.
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
July 25, 1891	5,823,500	Some bright bodies	None	Normal	Normal	102.0	66	48	July 25.—Heifer, 2 years old; received June 6, 1891, from Maryland. Placed in field I to-day, and a considerable number (200–300) of young ticks placed on rump and neck, and about the same number daily until August 4, inclusive. (For source of ticks see No. 158.)
July 31, 1891	4,857,000	....do	....do	....do	....do	102.6	66	42	
Aug. 3, 1891	4,880,000	Two bright bodies	....do	....do	....do	102.0	78	30	
Aug. 6, 1891	4,828,000	Some bright bodies	....do	....do	....do	106.4	96	120	
Aug. 7, 1891	4,040,000	1 per cent large parasites.	Same as in fresh preparations.	....do	....do	107.1	96	96	
Aug. 8, 1891	3,250,000	....do 1–2 per cent bright bodies.	....do	....do	....do	106.8	102	96	Losing flesh rapidly; is dull and weak. Moves slowly when urged, and roams uneasily and aimlessly about.
Aug. 10, 1891	2,102,500	A few large parasites.	None	....do	....do	107.3	129	123	August 15.—Has continued thin and weak. Appetite now returning and general condition improving.
Aug. 11, 1891	2,026,600	None	....do	....do	Normal; one hæmatoblast.	105.8	126	108	
Aug. 14, 1891	2,181,800	....do	Several pairs of large parasites.	10 per cent of macrocytes.	5 per cent tinted and punctate corpuscles.	105.1	90	120	August 16.—Twenty-five adult ticks collected.
Aug. 17, 1891	1,819,000	....do	None	30 per cent of macrocytes.	15 per cent tinted and punctate corpuscles.	102.8	96	90	
Aug. 22, 1891	1,926,300	One pair large parasites.	....do	....do	A few tinted and punctate corpuscles.	103.6	80	64	
Aug. 26, 1891	2,414,000	None	....do	....do	Very few tinted and punctate corpuscles.	102.5	75	54	Ticks have nearly all matured and been picked off or have dropped off.
Sept. 5, 1891	1,947,300	....do	....do	Very few macrocytes.	....do	102.0	66	42	September 30.—Improvement since August 15 has been very slight.
Sept. 15, 1891	3,280,700	....do	....do	Macrocytes rare	Normal	101.4	72	48	October 17.—Still thin and rather weak.
Oct. 7, 1891	3,473,600	....do	....do	....do	....do	99.8	54	12	A large number of young ticks, probably 12 to 15 days old, on this animal. Progeny of ticks applied in July and August.
Oct. 27, 1891	3,987,000	One bright body	....do	....do	....do	101.0	....	20	Several hundred ticks on animal, some full grown.
Nov. 9, 1891	4,121,200		....do	Normal	....do	102.2	78	30	December 21.—General condition fair.
Aug. 26, 1892	5,285,700 (white 10,000)		....do		....do	102.0	72	48	Reëxposed in field VI (North Carolina cattle with ticks). For temperature, see p. 290.
Sept. 12, 1892	5,275,000 (white 7,500)	None	....do	Normal	....do	102.0	88	52	
Sept. 22, 1892	7,086,000 (white 9,876)		....do		....do	101.2	68	20	October 1.—Slight loss in flesh noted.

No. 167 (native).

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature record see pp. 287, 289.)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
Aug. 27, 1891	6,500,000	....	None	....	Normal	101.8	65	60	Heifer, 3½ years old; received June 22, 1891, from Maryland. July 2.—Placed in field XI (North Carolina cattle without ticks). August 29.—Dull with partial loss of appetite.
Aug. 31, 1891	4,183,300	Some bright bodies	....do	Normal	......do	107.0	72	96	A small number of ticks on animal. These not quite so large as hemp seeds.
Sept. 2, 1891	3,041,700 (white, 5,561)	....	About 1 per cent infected corpuscles.	....do	......do	106.8	84	100	Intraglobular parasites, irregular in form, about 1 μ in diameter.
Sept. 3, 1891	2,015,400 (white, 7,692)	....	A few infected corpuscles.	....do	......do	106.0	108	68	
Sept. 4, 1891	1,773,000 (white, 10,400)	None	None	....do	......do	104.8	108	80	Urine of last evening free from hæmoglobin; trace of albumen. September 5.—Quite weak and thin; has been losing flesh since August 29.
Sept. 12, 1891	2,016,600 (white, 11,666)	....do	....do	20 per cent macrocytes.	Some punctate and tinted cells and a few hæmatoblasts.	100.6	72	66	Ticks, very few on animal; ticks have been picked off, as in case of No. 161.
Oct. 8, 1891	3,627,400 (white, 9,803)	....do	....do	Many macrocytes..	No stained forms	103.0	72	60	October 17.—Is now nearly recovered; improvement began September 7.
Nov. 3, 1891	5,724,100 (white, 15,511)	....do	....do	Normal	Normal	101.5	72	28	December 21.—General condition good.
July 20, 1892	....	....	....	....	....	......	....	....	Reëxposed in field VI (North Carolina cattle with ticks).
July 28, 1892	6,425,000 (white, 15,000)	Some bright bodies	....	Normal	....	101.5	76	96	
Aug. 22, 1892	6,187,500 (white, 10,000)	....do	None	....do.	Normal	102.8	78	84	
Aug. 31, 1892	5,675,000 (white, 21,250)	....do	....do	Some macrocytes .	More or less variation in size of corpuscles; several punctate cells.	102.4	72	60	
Sept. 27, 1892	5,499,000 (white, 9,876)	None	....do	....do	Considerable number of macrocytes.	102.0	84	48	Probably a very slight attack; general condition not affected.

No. 168 (native).

Date.	Number of red corpuscles.	Parasites in red corpuscles. In fresh preparations.	Parasites in red corpuscles. Dried and stained.	Condition of red corpuscles. In fresh preparations.	Condition of red corpuscles. Dried and stained.	Temperature.	Pulse.	Respiration.	Remarks.
Aug. 3, 1891	6,762,500	A small number bright bodies.	Negative	Normal	Normal	102.5	60	32	Heifer, 4 years old; received June 22, 1891, from Maryland. Placed in field XII.
Aug. 4, 1891	4,988,700	....	do	do	do	102.6	68	32	2,268 grams (about 5 lbs.) of blood drawn from right jugular vein.
Aug. 5, 1891	4,652,700	Negative	do	do	do	101.8	60	32	2,325 grams (about $5\frac{1}{8}$ lbs.) of blood drawn.
Aug. 6, 1891	5,227,800	One bright body	do	do	do	102.4	63	36	No blood drawn to-day.
Aug. 7, 1891	3,820,000	Negative	do	do	do	102.5	66	48	3,827 grams ($8\frac{7}{16}$ lbs.) of blood drawn.
Aug. 8, 1891	3,094,600	A few bright bodies	do	10 per cent macrocytes.	2–3 per cent punctate corpuscles.	102.3	63	48	4.251 grams ($9\frac{3}{8}$ lbs.) of blood drawn.
Aug. 10, 1891	2,253,700	Negative	do	20 per cent macrocytes.	15 per cent punctate and tinted cells.	102.9	72	66	4,989 grams (11 lbs.) blood drawn.
Aug. 11, 1891	2,143,000	A few bright bodies	do	do	do	113.5	72	72	
Aug. 12, 1891	2,114,750	Negative	do	do	15 per cent punctate and tinted cells; 1 hæmatoblast.	102.6	72	78	
Aug. 14, 1891	2,538,400	do	do	Many macrocytes.	5 per cent punctate and tinted cells.	101.7	66	54	Animal has fallen away in marked degree.
Aug. 17, 1891	3,202,000	do	do	do	A few punctate and tinted cells.	101.6	90	54	
Aug. 22, 1891	3,200,000	do	do	do	Stained cells absent	102.0	60	52	
Aug. 29, 1891	4,325,000	do	do	A few macrocytes.	do	102.0	48	30	
Sept. 8, 1891	4,784,000	do	....	do	do	101.8	54	42	
Sept. 30, 1891	1,961,500	do	Negative	Many macrocytes.	A few punctate and tinted cells.	104.2	72	48	Texas fever infection from some undetermined source since the last examination.
Oct. 15, 1891	3,283,700	Several bright bodies.	do	do	....	101.4	56	24	
Oct. 31, 1891	4,226,000	....	do	A few macrocytes.	....	101.0	60	20	

No. 169 (*native*).—Cow, 8 years old, received May 28, 1891, from Maryland.

September 1.—Placed in field VI (North Carolina cattle with ticks). Temperature, 101.6; pulse, 66; respiration, 42. Red corpuscles, 5,423,000. Fresh and stained preparations show nothing abnormal.

September 7.—Temperature, 101.2; pulse, 60; respiration, 60. Red corpuscles, 4,966,600; white, 10,000. A few ticks and many lice on this animal.

September 12.—Temperature, 103.4; pulse, 72; respiration, 48. Red corpuscles, 4,335,400; white, 12,903. Nothing abnormal in fresh and stained preparations.

September 14.—Found dead early this morning; abdomen distended with gas. Autopsy a few hours later.

Animal weighs about 900 pounds. A large number of small ticks on thighs, escutcheon, udder, neck, and axilla. On removing the skin a small tumor observed in the left flank, which proves to be a hernia of a coil of the ileum. Slight extravasation surrounding the opening in abdominal muscles. The peritoneum covering sac very hyperæmic, similarly the mucous membrane of the involved coil. No strangulation. The protrusion probably occurred a short time before death.

Heart shows punctiform ecchymoses over left ventricle. A small white clot in this cavity. The right ventricle contains a large dark clot. Lungs œdematous.

Spleen weighs 3½ pounds. Pulp soft; not so dark as in the average case of this disease.

Liver weighs 13 pounds. Advanced post-mortem changes. In the gall bladder some turbid bile.

Kidneys apparently unchanged. Bladder contains a small quantity of turbid urine free from hæmoglobin. It is alkaline and contains much albumen.

Digestive tract. Contents of third stomach dry, and somewhat impacted. Fourth stomach normal. Mucosa of upper jejunum and of a portion of cæcum markedly injected. The other portions normal, with exception of the prolapsed portion of ileum.

The various tissues show advanced post-mortem changes, and contain large post-mortem bacilli. Intraglobular parasites are very scarce in all the organs. Those present have the usual roundish form as found in the dead animal, and occur singly or in pairs. (For temperature, see p. 286.)

No. 170 (*native*).—Heifer, 1 year old received June 6, 1891. Kept in field XII.

September 30.—Temperature, 101.8; pulse, 60; respiration, 40. Red corpuscles, 4,300,000; white, 12,000. Nothing abnormal in fresh and stained preparations. This animal was not used in any experiment, but its blood was examined on this date owing to the unexpected appearance of Texas fever in this field at this time.

No. 172 (*Southern*).—Cow, 6 to 7 years old, received July 2, 1891, from near New Berne, N. C., and placed in field VI (North Carolina cattle with ticks).

December 21.—Removed and sold.

No. 173 (*Southern*).—Cow, 3½ years old, received July 2, 1891, from near New Berne, N. C., and placed in field XI after the ticks had been carefully picked off by hand. (North Carolina cattle without ticks.)

December 21.—Removed and sold.

No. 174 (*Southern*).—Heifer, 3½ years old, received July 2, 1891, from near New Berne, N. C., and placed in field VI (North Carolina cattle with ticks).

December 21.—Removed and sold.

No. 175 (*Southern*).—Cow, 4 years old, received July 2, 1891, from near New Berne, N. C., and placed in field XI, after the ticks had been carefully picked off by hand (North Carolina cattle without ticks).

December 21.—Removed and sold.

No. 176 (*Southern*).—Cow, 6 years old, received July 2, 1891, from near New Berne, N. C., and placed in field XI after the ticks had been carefully picked off by hand.

December 21.—Removed and sold.

No. 177 (*Southern*).—Cow, 5 years old, received July 2, 1891, from near New Berne, N. C., and placed in field VI (North Carolina cattle with ticks).

October 20.—Removed and sold.

No. 178 (*Southern*).—Cow, 4 years old, received July 2, 1891, from near New Berne, N. C., and placed in field VI (North Carolina cattle with ticks).

December 21.—Removed and sold.

No. 179 (*Southern*).—Cow, 5 years old, received July 2, 1891, from near New Berne, N. C., and placed in field XI, after the ticks had been carefully picked off by hand (North Carolina cattle without ticks).

December 21.—Removed and sold.

No. 180 (*native*).—Heifer, age 2 years, received July 25, 1891, from Maryland. Placed in Field I. From this date to August 4, inclusive, about 20 to 30 young ticks were placed on this animal daily. (See No. 158 for source of ticks.)

July 25.—Temperature, 102.4; pulse, 80; respiration, 48. Red corpuscles, 5,396,800. In fresh preparations a few corpuscles containing bright bodies. Stained preparations negative.

July 31.—Temperature, 104; pulse, 70; respiration, 30. Corpuscles, 4,462,700. Fresh and stained preparations negative.

August 3.—Temperature, 102.1; pulse, 60; respiration, 30. Corpuscles, 4,560,000. Fresh and stained preparations negative.

August 6.—Temperature, 106.7; pulse, 72; respiration, 48. Corpuscles, 4,636,300. Blood examination negative.

August 8.—Losing flesh and becoming weak.

August 10.—Animal very weak and thin. Temperature, 107.7; pulse, 120; respiration, 87. Corpuscles, 1,864,900. In fresh and stained preparations a very small number of corpuscles detected, containing parasites of medium size.

August 12.—Died between 6 and 7 a. m.

Autopsy (9 a. m.). Animal has lost considerable flesh since the beginning of the fever. Weighs now about 400 pounds.

Ticks on the inner surface of thighs, on abdomen, and neck. On the average about one to a square inch. They are still small, about ¼ inch long.

Heart surface well sprinkled with ecchymoses. These are most numerous on the left ventricle. Both sides of the heart contain rather large, dark, firm clots, that in the right being the larger. Considerable blood extravasation under endocardium of left ventricle, especially marked on septum.

Lungs somewhat œdematous.

Spleen weighs 2¾ pounds. Small blood tumors along the course of the vessels under capsule.

Liver weighs 10 pounds; enlarged, edges rounded off. The parenchyma has a yellowish hue. When examined with a lens the yellow coloration is found limited to the tissue around the hepatic vessels. In fresh sections bile injection appears restricted to small areas. Fatty degeneration well advanced. The hepatic cells contain lumps of pigment, and red needle-like crystals are sprinkled over the section. Bile in gall bladder very viscid, and holds in suspension a large quantity of flocculent matter.

Kidneys deeply congested throughout. In bladder 3 quarts of urine, which has a light claret color. Specific gravity, 1018. Acid reaction. Albumen, according to Esbach, 0.2 per cent. On standing, urates are deposited.

Digestive tract: A few hemorrhages on lamellae of fourth stomach. In the large intestine more or less pigmentation of mucosa. Contents dry and massed into fine balls. Intestines otherwise normal.

In preparations of heart's blood, parasites are rare. They are in general roundish in outline and but one within a corpuscle. In the liver there are about 1 to 2 per cent; in the spleen still less. In one preparation of the spleen pulp a capillary is

seen filled with infected corpuscles only. Each contains two parasites. In the kidney not less than 10 per cent of the corpuscles contain either one or two parasites. The large post-mortem bacillus is likewise present in small numbers.

No. 181 (native).—Cow, 2½ years old, received August 28, 1891.

September 5.—Placed in field VI (North Carolina cattle with ticks). Temperature, 101.6; pulse, 54; respiration, 90. Red corpuscles, 5,673,400. White, 12,245. Nothing abnormal in stained preparations.

September 12.—Temperature, 101; pulse, 72; respiration, 60. Red corpuscles, 5,707,000. White, 6,900. Both stained and fresh preparations negative.

September 18.—Temperature, 106.4; pulse, 66; respiration, 102. Red corpuscles, 4,134,600. White, 7,692. In stained preparations two corpuscles found infected with large parasites.

September 19.—Temperature, 106.2; pulse, 76; respiration, 100. Red corpuscles, 2,970,000. White, 4,477. In stained preparations from one-half to 1 per cent infected corpuscles. From this animal blood was withdrawn to-day from the left jugular and injected into the jugular of No. 185 and 186. After the withdrawal of blood the animal refuses to rise. It was killed by a blow on the head and examined immediately.

Autopsy: Animal weighs about 750 pounds; in fair condition. Ticks on the thighs, udder, pubic region, abdomen, and axilla in moderate numbers.

Firm attachment of omentum and slight adhesions of spleen to wall of abdomen.

Heart and lungs normal. Blood withdrawn before death and placed in beaker; clots readily and firmly. In two hours much serum had been pressed out.

Spleen weighs 4 pounds. Considerably enlarged. Pulp, dark and soft, concealing Malpighian bodies and trabeculæ.

Liver weighs 15 pounds. Enlarged, but nearly normal in appearance. The intralobular capillaries are distended with blood. No fatty degeneration and bile injection as yet noticeable in fresh sections. The hepatic cells contain minute pigment granules. Gall bladder contains about one-half pint of bile which is considerably darker than in the normal state, but holds only a small quantity of flocculent matter in suspension.

Kidneys more or less congested. In fresh sections capillaries densely packed with red corpuscles. The urine in the bladder is still free from coloring matter of the blood. Specific gravity, 1024. Strongly alkaline. Trace of albumen.

Digestive tract normal.

The distribution of the infected corpuscles examined both in fresh and stained preparations. In the tissues the following approximate numbers were observed:

Blood of heart and skin, ½ to 1 per cent; spleen, liver, and marrow, ½ to 1 per cent; kidney 20 to 30 per cent; heart muscle (capillary blood), 50 per cent or more (Plate VII, Fig. 1). The parasites were likewise readily found in unstained preparations. In all of these corpuscles the bright bodies frequently referred to were present. The parasites were all pear-shaped, usually a pair in a corpuscle. In the fluid expressed from the heart muscle many free pairs were seen. (For temperature record, see p. 286.)

No. 182 (native).—September 19.—A portion of the heart muscle of No. 181, just dead, was cut up into small pieces and pounded in a sterile mortar with normal sterilized salt solution. The reddish fluid was passed through filter paper at 1 p. m. and kept at 95°–105°F. until 2 p. m., when 14 cc. (one syringe full) was injected into the left jugular of No. 182 (see, also, Nos. 185 and 186). The subsequent history of this case is comprised in the following table:

No. 182 (native).

[Heifer, 3½ years old. Received from Maryland August 28, 1891, and placed in uninfected field II.]

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature see pp. 288, 290.)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
Sept. 19, 1891	6, 030, 700 (white, 16, 903)	A few bright bodies.	None	Normal	Normal	102. 5	66	42	Intraveneous injection of juice of heart muscle of No. 181 mixed with sterile salt solution as indicated above: 14 cubic centimeters injected.
Sept. 28, 1891	4, 253, 700 (white, 10, 447)	1 per cent bright bodies; a few large parasites.		do	do	106	72	108	Urine of normal color; animal is dull and does not eat.
Sept. 30, 1891	2, 285, 700 (white, 4, 762)	None	Some large parasites.	do	do	105. 4	90	78	Losing flesh rapidly; weak and thin.
Oct. 9, 1891	2, 377. 300 (white, 9,604)	do	None	Some macrocytes	Many punctate and tinted corpuscles.	100. 2	58	16	General condition has remained about the same. October 17. Has begun to improve since October 10.
Oct. 21, 1891	3, 829, 500	do	do	do		103	60	28	Removed to field IV for stabling.
Nov. 11, 1891	5, 150, 000 (white, 10,000)	do	do	Normal	Normal	102. 5	72	36	December 21.—General condition now quite fair.
Aug. 26, 1892	6, 225, 000 (white, 12,500)		None		Normal	102. 2	84	60	Re-exposed to-day in field VI. (North Carolina cattle with ticks.)
Sept. 13, 1892	5, 680, 000 (white, 8,974)		do		do	103. 6	68	36	
Sept. 22, 1892	4, 579, 000 (white, 12,903)		do	Many macrocytes.	Several punctate and tinted corpuscles.	101. 4	84	28	
Oct. 10, 1892	5, 195, 000 (white, 10,975)		do		A few macrocytes; one punctate cell.	103	80	40	Slight attack, although general condition unchanged.

No. 183 (*native*).—Heifer, 2½ years old, received August 28, 1891, from Maryland.

August 29.—Receives into right jugular vein 5 cc. of fluid made by crushing young ticks, 1½ months old, in sterile water and filtering through filter paper. (See No. 165.) Placed in field IV.

The following figures were obtained before the injection: Temperature, 101.2; pulse, 72; respiration, 54. Red corpuscles, 5,770,000. Fresh and stained preparations of blood normal.

September 5.—Temperature, 101.2; pulse, 84; respiration, 42. Red corpuscles, 5,583,300; white, 11,666. Microscopic examination, negative.

September 10.—Temperature, 101; pulse, 60; respiration, 36. Red corpuscles, 6,557,000; white, 9,615. Examination of blood, as before.

September 18.—Temperature, 102.7; pulse, 72; respiration, 60. Red corpuscles, 6,000,000; white, 14,035. Examination of blood, as before.

October 15.—Temperature, 101.8; pulse, 80; respiration, 36. Red corpuscles, 6,206,800. In fresh preparations, a few bright bodies; stained preparations, negative.

October 20.—No result to date. Animal sold. (For temperature record, see p. 287.)

No. 184 (*native*).—Heifer, 2 years old, received August 28, 1891. Kept in uninfected field II.

August 29.—Temperature, 102; pulse, 96; respiration, 54. Red corpuscles, 7,530,000. Fresh and stained preparations, normal.

September 15.—Placed in field VI (North Carolina cattle with ticks). Temperature, 101.6; pulse, 78; respiration, 40. Red corpuscles, 5,826,900; white, 5,769. Fresh and stained preparations, normal.

September 29.—Temperature, 106.2; pulse, 90; respiration, 84. Red corpuscles, 4,350,000; white, 10,000. In both fresh and stained preparations a few corpuscles found infected with large parasites.

October 1.—Temperature, 103.2; pulse, 108; respiration, 60. Red corpuscles, 1,822,500; white, 6,451. Parasites as on September 29.

October 2.—Found dead at 6 a. m. Animal heat not entirely dissipated.

Autopsy: Weight of animal, about 500 pounds. Condition still good. Vew few ticks on thighs.

In the abdomen the omentum is injected in patches.

Lungs slightly œdematous. Several small foci of red hepatization. In both heart cavities a considerable amount of fluid blood.

Spleen weighs 3½ pounds; enlarged; pulp dark and softened. Liver weighs 11½ pounds, of a markedly yellowish color and doughy to the touch. In fresh sections the bile injection (Plate III, Fig. 3) and the fatty degeneration of the parenchyma very extensive. Large bundles of minute acicular red crystals scattered over the section. Gall bladder contains about 10 ounces of very thick bile, holding much flocculent matter in suspension and scarcely flowing from the bladder.

Kidneys uniformly congested. Pelvis dotted with ecchymoses. In fresh sections capillaries observed gorged with red corpuscles. Bladder contains 2 quarts of urine having a wine-red color. Acid. sp. gr. 1,018. Abundant flocculent precipitate, with acetic acid in the cold. Albumen, according to Esbach, 0.2 per cent. On standing a slight deposit of urates.

Digestive tract normal.

Stained preparations of the blood and organs contained infected corpuscles approximately as follows:

	Per cent.
Blood (subcutaneous and cardiac)	½–1
Spleen	2–3
Kidney and liver	20 or more.
Heart muscle	10–15

The parasites are roundish, about 1 μ in diameter. Some corpuscles contain two, others but one. (For temperature record, see p. 286.)

No. 185 (native).

[Cow, 7 years old. Received September 4, 1891, from Maryland and placed in field II. September 19, 11 a. m. Two syringes full of blood are withdrawn from the left jugular vein of No. 181 by making an incision through the skin over the vein and piercing the wall of the vein with the needle of the syringe. The time elapsing between the withdrawal of the blood from No. 181 and its injection into No. 185 was one to two minutes. Subsequent trials showed that the blood remained fluid in the syringe for at least ten minutes. The syringe holds 14 cubic centimeters, hence 28 cc. was injected in all.]

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature see pp. 288, 289.)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
Sept. 8, 1891	4,880,000	....	None	....	Normal	102.8	72	60	
Sept. 24, 1891 (3 p. m.)	4,146,000	A few large parasites.	....do	Tend to shrivel...	....do	107.8	69	100	Urine of normal color.
Sept. 25, 1891	3,233,000	....do	....do	....do	....do	107.4	108	78	Appetite partly lost; animal dull.
Sept. 26, 1891 (1:30 p. m.)	2,507,400	½–1 per cent large parasites.	....	....	....do	107.2	80	112	Appetite entirely lost. Losing flesh. Urine of normal color.
Sept. 28, 1891	....	....	....	....	....	......	....	....	Urine of normal color.
Sept. 29, 1891	1,754,300 (white, 12,280)	None	None	....	Some punctate corpuscles.	102.2	90	74	Has become very thin and weak.
Oct. 9, 1891 (9:40 a. m.)	1,037,700 (white, 15,094)	Some large parasites (Pl. v, Fig. 3).	....	Many macrocytes.	5 per cent punctate corpuscles.	97.8	96	18	Dropped a 3 to 4-months' fœtus last night. Has not improved since September 30. Very low this morning, apparently in dying condition.
					5 per cent tinted corpuscles.	......	....	....	October 17.—Has been slowly gaining ground since October 10. October 12, removed to field IV for stabling.
Oct. 21, 1891	2,500,000	None	None	Some macrocytes .	....	103.6	80	36	
Nov. 11, 1891	4,813,000	....	....do	....	....	101.8	76	48	December 21.—Now in fair condition.
Aug. 26, 1892	6,050,000 (white, 16,250)	....	Several paired and single parasites.*	....	Normal	103	78	66	Reëxposed to-day in field VI (North Carolina cattle with ticks).
Sept. 13, 1892	6,328,000 (white, 7,594)	....	One large parasite.	....	....do	102.5	80	52	
Sept. 22, 1892	5,573,000 (white, 8,536)	....	None	....	....do	101.8	72	48	October 1.—Exposure negative. General condition unchanged.

*These Texas fever parasites were probably carried in the blood since last year. See observations on Southern animals, p. 118.

No. 186 (*native*).—Red cow, from 10 to 12 years old, received from Maryland September 4, 1891, and placed in uninfected field II.

September 8.—Temperature, 102.2; pulse, 72; respiration, 48. Red corpuscles, 4,980,700; white, 13,461.

September 19.—From the jugular vein of No. 181, sick with Texas fever, a syringe full of blood (14 cc.) was withdrawn and injected directly into the right jugular of No. 186. (For details see the preceding case.) The blood of No. 186 was carefully examined microscopically before the injection. In a fresh preparation one minute round body, 1 μ in diameter, seen in a corpuscle, slightly changing place.

September 25.—Temperature, 106; pulse, 72; respiration, 78. Red corpuscles, 4,761,905. In preparations of fresh blood several corpuscles detected with large pyriform parasites, each with a dark point (nucleus?). In stained preparations none observed.

September 26, 2:30 p. m.—Temperature, 107; pulse, 96; respiration, 108. Red corpuscles, 4,333,300. In fresh and stained preparations a small number of corpuscles containing large parasites.

September 28, 2:15 p. m.—Temperature, 101.2; pulse, 108; respiration, 60. Red corpuscles. 2,123,077; white, 4,615. From 1 to 2 per cent of corpuscles contain amœbiform parasites.

The animal stands trembling and quivering, swaying with her hind quarters, and scarcely able to remain on her feet while a few drops of blood are being collected from a skin incision for examination. Soon after she falls down and remains on the ground.

At 3:30 p. m. a syringeful of blood (7 cc.) is withdrawn from a jugular vein to inoculate several pigeons. The blood was withdrawn as described under No. 185 above. After this insignificant operation the cow goes into convulsions and dies.

Autopsy notes: Animal has lost much flesh. Weighs now about 700 pounds.

Lungs normal. Heart firmly contracted. Considerable extravasation under the epicardium of left ventricle, much less on the right ventricle. Many ecchymoses and small hæmatomata under endocardium of both ventricles. Heart muscle shows slight fatty degeneration. In the serum expressed from the heart muscle a large number of large parasites both free and within corpuscles. In stained preparations from 30 to 40 per cent of all corpuscles are infected. Many parasites in pairs. (Plate IV, Fig. 5.)

Spleen weighs $4\frac{9}{16}$ pounds. Very much enlarged. Tortuous injected vessels on capsule with hemorrhages along their course. The pulp is very dark and very soft. Malpighian bodies invisible. In teased preparations examined fresh there are many large cells containing from two to eight red corpuscles. Two capillaries seen, in which nearly every corpuscle is infected. Pigment present in small quantities. In stained preparations about 8 to 10 per cent corpuscles contain large parasites.

Liver weighs 14 pounds. Some old adhesions on the right between it and diaphragm. Tissue rather firm, color departing slightly from the normal. Yellowish dots and lines are seen on section corresponding to the zone around hepatic veins (intra and sub lobular). In several larger branches of the hepatic vein are thrombi. In fresh sections and teased preparations, bile injection localized to small areas around intralobular viens. In stained preparations from 20 to 30 per cent of the corpuscles infected.

Bile very thick and flaky, holding a large amount of amorphous matter in suspension.

Considerable œdema in the fatty tissue around kidneys. The organs are in a condition of general congestion; all normal markings effaced or indistinct. Glomeruli prominent. Cut surface granular. Many ecchymoses in pelvis. In fresh sections all capillaries choked with red corpuscles. In stained preparations nearly all corpuscles contain parasites. There are also many free forms. In sections of tissue (hardened in Müller's fluid and alcohol and embedded in chloroform paraffine)

stained in hæmatoxylin the engorged capillaries contain only infected red corpuscles (Pl. VII, Fig. 2). Structural changes not noticeable.

In bladder, 2 quarts of urine of a dark reddish color. No sediment on standing. Specific gravity, 1015. Feebly acid. About 0.05 per cent albumen (Esbach). Precipitate with acetic acid without heat.

The mucosa of fourth stomach has a bluish red to bright red color. Digestive tract otherwise not affected. (For temperature record, see p. 288.)

No. 187 (*native*).—Calf of No. 160. About 4 months old (Sept. 21), but no larger than a calf 4 weeks old (first calf of a small heifer).

September 21.—Caught after much chasing and placed in field VI (North Carolina cattle with ticks) with No. 160. Temperature, 105; pulse, 117; respiration, 52. Red corpuscles, 5,870,000; white, 22,222. Nothing abnormal in fresh and stained blood preparations.

October 13.—Excited on being chased and caught. Temperature, 103.5; pulse, 132; respiration, 30. Red corpuscles, 5,774,000. Nothing abnormal in fresh and stained preparations.

November 12.—Temperature, 102.4; pulse, 92; respiration, 60. Red corpuscles, 7,224,000; white, 15,517. Corpuscles normal. Result of exposure, negative.

No. 188 (*native*).—Cow, 6 years old, received September 25, 1891, from Maryland, and placed in field XII.

October 1.—Temperature, 100.8; pulse, 60; respiration, 36. Red corpuscles, 5,596,400; white, 8,772. In fresh preparations a considerable number of corpuscles with bright bodies. In stained preparations nothing abnormal.

October 20.—Sold.

No. 189 (*native*).—Cow, 7 years old, received September 25, 1891, from Maryland, and placed in field XII.

October 1.—Temperature, 101; pulse, 66; respiration, 30. Red corpuscles, 5,706,800; white, 10,344. Some bright intraglobular bodies; corpuscles otherwise normal.

October 20.—Sold.

No. 190 (*native*).—Cow, 6 years old, received September 25, 1891, from Maryland, and placed in field XII.

October 1.—Temperature, 100.2; pulse, 65; respiration, 60. Red corpuscles, 5,966,000; white, 10,169. Some bright intraglobular bodies detected in fresh preparations.

October 20.—Sold.

No. 197 (*native*).—Grade Jersey, 6 years old, received June 3, 1892, from District of Columbia. Placed in field X to test survival of ticks and Texas fever infection of 1891. Gives birth to calf No. 226, June 20.

August 27.—Up to this date no ticks had appeared on animals in this field. No evidence of infection as shown by the condition of the animal and the following results of the blood examination. Red corpuscles, 5,012,500. White, 6,250. In preparations of fresh blood many red corpuscles contain bright bodies. Stained preparations negative. Injection into left jugular 14 cc. (one syringeful) of blood from sick native No. 222 prepared in the following manner:

No. 222 was secured in a rectangular box and the head raised and fastened in such a way as to be immovable and to stretch the left side of the neck. This was shaven over the jugular vein and the skin disinfected with 0.1 per cent mercuric chloride. With a flamed scalpel the skin and wall of the jugular vein, kept tense by pressure applied at the root of the neck, was incised. The blood flowing freely was caught in sterilized bottles containing glass beads and defibrinated by shaking for ten minutes. The bottles were then placed in a water bath at 40°–42° C. until used for inoculation. (For the condition of the blood of No. 222 on this day see this appendix under No. 222.) The blood drawn about 11:05 a. m. was injected into this animal at 11:15 a. m.

Placed in a fenced-off portion of field XII (XII_a).

September 4.—Dies suddenly about 9:30 a. m., after having shown an elevated temperature 4 days.

Autopsy notes: The animal having died on Sunday, only such examination was made on the spot at 2:30 p m. as would determine the cause of death. The following notes amply demonstrate Texas fever:

Spleen very large, blackish, normal markings effaced on the cut surface. The liver has a bluish slate color mottled with minute paler dots. On section this mottling is yellowish and confined to the tissue around the intralobular veins, the remainder of the cut surface being a brownish color. In fresh sections much fatty degeneration, also roundish bodies (crystals?) larger than red corpuscles which are refrangent like fat globules and have a peculiar yellowish red color. Bile injection not observed in such sections.

Kidneys pale brownish red with a granular cut surface and usual markings effaced. Epithelium of convoluted tubules markedly granular. In pelvis extensive patches crowded with small ecchymotic spots. Urine, claret colored. Specific gravity, 1017. Fine precipitate with acetic acid cold. Albumen (Esbach), 0.35 per cent. In the deposit collected by standing in refrigerator, a few red corpuscles, granular masses, and mucus.

The skin over abdomen shows (5 hours after death) dried blood crusts $\frac{1}{4}$ to $\frac{1}{2}$ inch apart, matting the hair together into little tufts. The skin under these places shows a bluish spot, and when incised a small collection of blood is found under the true skin.

In the spleen and liver very few corpuscles infected with paired roundish parasites 1 to 1.5 μ in diameter. In the kidneys about 10 per cent are infected. (For temperature record, see p. 294.)

No. 198 (*native*).—Cow, 7 years old, received June 3, 1892, from Prince George County, Md., and kept on an adjoining farm until June 30, then transferred to field III.

July 6.—Injected into left jugular vein 28 cc. (two syringefuls) of blood drawn from the jugular vein of North Carolina cow No. 217. The transfer of blood from the vein of one animal to that of the other was made in the same syringe and occupied not more than two minutes. The syringe had been warmed previously to 105° F., after being thoroughly disinfected in 5 per cent carbolic acid and boiling water. (See No. 206 for a similar injection.)

The following table gives in brief the clinical history of the animal up to the time of death:

No. 198 (native).

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature record see p. 292.)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
July 5	6,625,000 (white, 8,750)		Negative		Normal	102.5	68	80	
July 7	6,291,666 (white, 10,416)		do		do	103	56	81	
July 9	6,237,500 (white, 20,000)		do		do	102.5	58	48	Stands with back slightly arched.
July 11	5,925,000 (white, 9,625)		do		do	102.2	52	68	
July 13	5,187,500 (white, 6,000)		do		do	105.2	64	96	Drooping of head and arching of back quite pronounced. Appetite unimpaired; continues to stand most of the time.
July 15	5,400,000 (white, 10,000)		do		do	104.5	64	80	Falling away in flesh. Very dull.
July 16	4,825,000 (white, 7,500)		Several paired and 7 to 8 unpaired parasites.		do	106.6	56	68	Appetite failing. Loss of flesh continues. Drooping of head and arching of back more marked.
July 18	3,112,500 (white, 5,000)	5–10 per cent irregular, roundish parasites, chiefly single.	As in fresh preparation.	Normal	do	106.4	96	92	Very dull and weak. Lies most of the time on left side with head extended and resting on the ground. Passes much claret-colored urine at 6 and 11:30 a. m.
July 19									Found unable to rise at 6 a. m. Dies at 11 a. m.

Autopsy about 1½ hours after death. Animal thin; weighs about 600 pounds; has lost about 200 pounds during illness.

Several small areas of intralobular and subpleural emphysema in the principal lobe of both lungs and in the right ventral lobe. The connective tissue of old pleural adhesions forms a fringe along lateral borders of principal lobes which is in a dark-red hyperæmic condition. A dark red, airless lobule in the right cephalic and the left principal lobe.

Slightly œdematous condition of the fat around heart case. Very marked ecchymosis of the ventricular surfaces of the heart, the discoloration extending in some places from ⅛ to $\frac{3}{16}$ inch into the heart muscle. Extensive extravasation beneath endocardium of left ventricle; slight extravasation in right ventricle. Blood from the heart coagulates promptly in beakers. The serum is much more deeply colored than that from healthy cattle.

Spleen weighs 5½ pounds. Capsule very much distended. Pulp dark brownish, still consistent in texture. Malpighian bodies barely visible on section.

Liver weighs 13¾ pounds (without gall bladder). It is paler than normal and shows a peculiar mottling with irregular yellowish-gray patches, each less than 1 mm. in diameter. On section the organ appears yellowish brown and the course of the intralobular veins is marked by yellowish-gray borders. In fresh sections fatty degeneration of the parenchyma and the bile stasis quite extensive. Sections were also examined from tissue hardened in Müller's fluid and alcohol. In these after staining with acid hæmatoxylin or alkaline methylene blue, only a narrow region of the acini bordering on the intralobular tissue was found free from necrotic changes. These were manifested by partial or total loss of the nucleus. The capillaries of these areas were in places very much distended and filled with red corpuscles, many of which contained parasites.

In the gall bladder about ½ liter of very thick, flaky bile.

The fat around kidneys contains a moderate amount of serous effusion. Kidneys enlarged (left, 1⅞ pounds; right, 2 pounds); capsule readily removable. Parenchyma of a uniform dark brownish red. Much serum flows from the cut surface. The glomeruli stand out as minute blood-red points. The tips of papillæ hyperæmic and the calices of the pelvis surrounding them ecchymosed. Microscopic examination of fresh sections shows extreme engorgement of all blood vessels.

Urinary bladder contains 1½ liters of urine having a dark port-wine color and barely translucent in a layer ¾ inch deep. No sediment on standing.

The second stomach adherent to the diaphragm by means of old connective tissue over an area 6 inches square. This tissue dark red, very hyperæmic. The mucosa of fourth stomach in the laminated portion is of uniformly pink color. The pyloric portion is beset with a number of irregular shallow erosions with hemorrhagic base. They vary from ½ to 2 inches in length, and are elongated in shape. The mesentery of duodenum (near portal fissure) is infiltrated with pale reddish serum. Mucosa of small intestine coated with a pasty bile-stained substance representing desquamated epithelium. Macosa of rectum congested in patches and containing fecal balls.

The pia covering the hemispheres of the brain injected and pigmented. The plexuses are considerably engorged with blood. No fluid in the ventricles and no abnormal appearance of the brain substance itself. In sections of the cerebral tissue hardened in Müller's fluid and alcohol and stained in hæmatoxylin capillaries could be traced for some distance in the white substance underlying the gray, which were filled completely with infected corpuscles. From one of the puncta vasculosa on the cut surface of the white substance of the cerebrum, while still fresh, a bit of tissue was crushed under a cover glass. In it a capillary was traced for some distance containing only infected corpuscles. In the choroid plexus of lateral ventricles many of the gorged capillaries are observed containing infected corpuscles only.

Stained cover-glass preparations from various tissues and organs were examined for infected corpuscles with the following results:

	Per cent.
Blood from subcutaneous vein, about	10
Spleen pulp	10
Liver tissue	10
Hyperæmic spot on omentum	10
Kidneys	50
Heart muscle (excluding free parasites)	30
Brain tissue	2–3
Choroid plexus of lateral ventricles	10–20
Hyperæmic adhesion of second stomach	10
Skeletal muscles	very few.

The parasites appeared in the red corpuscles, both single and in pairs. The numerical relation, in the different preparations, of single and double bodies varied more or less, the former being in some regions in the majority, in others in the minority. The single bodies were always roundish, the double bodies roundish or pyriform. The best pyriform bodies appeared in preparations of corpuscles from the heart muscle, next in the circulating blood, and in the capillaries of organs excepting spleen, liver, and kidneys.

No. 199 (*native*).—Cow, 8 years old, received June 3, 1892, from the District of Columbia, and placed in field X to test survival of ticks and Texas fever infection of 1891.

September 12.—No ticks, or evidence of Texas fever infection up to date. Calf due in October. Temperature, 102.4. Red corpuscles, 4,820,000. Nothing abnormal in fresh and stained preparations excepting a slight variation in size.

No. 200 (*native*).—Cow, 8 years old, received from Charles County, Md., June 20, 1892, and kept on an adjoining place until August 30. Injected into left jugular vein 14 cc. (one syringeful) of defibrinated blood from sick native No. 222, being a portion of the same blood injected into Nos. 197, 227, and 228, and kept at a temperature of 50° F. in a refrigerator since August 27. (See No. 197 for details.)

Placed with above-mentioned cases in a fenced-off portion of field XII (XII_a).

No. 200, before the operation, had a temperature of 102.3° F. Red corpuscles, 5,400,000. In fresh preparations of blood a considerable number contain the bright bodies. Stained preparation negative.

September 6.—Temperature, 107; pulse, 75; respiration, 72. Red corpuscles, 3,950,000; white, 7,500. In fresh preparations of blood, probably 2 per cent of corpuscles contain large parasites of irregular outline. The corpuscles themselves are darker in color and wrinkled and notched along border. Some contain bright bodies. In stained preparation some of the intraglobular parasites are in pairs and pyriform, others single and irregular in outline.

September 8.—Dies about 8:30 a. m.; autopsy three hours later. Animal thin. No skin lesions. In abdominal cavity hyperæmic patches on omentum. Gelatinous œdema between spleen and paunch.

Lungs, normal. Marked ecchymosis of the epicardium and endocardium of the ventricular surfaces of the heart.

Spleen weighs 4⅝ pounds. Pulp has a blackish homogeneous appearance. Markings of cut surface effaced.

Liver weighs 17 pounds. Has a brownish color, mottled with paler dots. On the cut surface, which is more or less uniformly brownish, the paler yellowish lines and dots corresponding to the tissue immediately around the intralobular veins appear only in localized patches. In sections of fresh tissue the intralobular capillaries markedly distended with red corpuscles; bile injection detected in small patches. Fatty degeneration very slight. Some hepatic cells contain pigment particles.

Gall bladder contains 1,200 cc. (3 pints) of very dark bile free from suspended matter.

Kidneys show the usual dark brownish-red appearance. The right weighs 2 pounds; the left 1¾ pounds. In fresh sections, the usual engorged condition of all the capillaries.

Urine has a dark port-wine color. Specific gravity, 1020. A few drops of acetic acid give a precipitate. Next day the filtrate is free from the blood-coloring matter. When tested for albumen by heat an abundant precipitate forms. Total albumen of the urine (Esbach) 1.2 per cent.

The walls of the small intestine show marked injection of the minute vessels. Contents fecal and bile stained. Mucosa uniformly pinkish red, due to injection of the capillaries.

Uterus contains a fœtus 4 to 5 months old.

Brain. Marked pigmentation of the pia of the frontal lobes and of the lateral aspect extending upon the base at the optic commissure. Similar pigmentation at the great transverse fissure. The minute vessels of pia injected. The injection most marked within the sulci as seen on cross section.

The Texas fever parasites were found in the various organs examined. They are either single or in pairs, mostly roundish, and nearly 1 μ in diameter. According to stained cover-glass preparations, the approximate infection is as follows:

Blood from subcutis contains 3 to 5 per cent infected corpuscles.

Spleen contains 5 per cent of infected corpuscles (parasites chiefly single).

Liver contains 30 per cent of infected corpuscles (parasites single and paired).

Kidneys contain 30 per cent of infected corpuscles (parasites single and paired).

Heart muscle contains 50 per cent of infected corpuscles (parasites chiefly in pairs).

In the choroid plexus where it enters the transverse fissure of the brain the parasites were observed within the capillaries in a fresh preparation. (For temperature record, see p. 294.)

No. 201 (*native*).—Cow, 5 years old, received June 20, 1892, from the District of Columbia. Kept in field between inclosures I and II until June 30, then placed in field VI for exposure to North Carolina cattle with ticks. (North Carolina cattle added July 1.) This animal is handled with considerable difficulty, hence the high-pulse rate as given below.

July 7.—Temperature, 102; pulse, 92; respiration, 44. Red corpuscles, 6,300,000. White, 8,750. In stained preparation several macrocytes and an occasional punctate corpuscle.

July 12.—Temperature, 102.6; pulse, 80; respiration, 44. Red corpuscles, 5,762,500; white, 9,555. Blood examination as before.

July 18.—Temperature, 102.8; pulse, 68; respiration, 72. Red corpuscles, 5,887,500; white, 10,000. More or less variation in the size of the corpuscles; examination otherwise negative.

July 20.—Transferred to unused field IV.

August 24.—Temperature, 101.8; pulse, 75; respiration, 54. Red corpuscles, 5,950,000; white, 10,000. Slight variation in size of the red corpuscles. A few bright intraglobular bodies in fresh preparations of blood. In stained preparations one deeply stained round intraglobular body, 2 μ diameter (nucleus of hæmatoblast.)

September 3.—Temperature, 102.4. Red corpuscles, 6,187,500; white, 7,500. Condition of blood corpuscles normal both in fresh and stained preparations.

September 27.—Temperature, 103 (animal excited by chasing). Red corpuscles, 6,875,000; white, 7,500. A moderate number of bright bodies detected in fresh preparations of blood. Stained preparations negative. (For temperature see pp. 289, 290.)

No. 202 (*native*).—Cow, 7 years old, received June 20, 1892, from Charles County, Md., and placed in field between inclosures I and II.

June 30.—Transferred to Field XI.

August 31.—Transferred to Field XIII. (See also No. 207.)

Injected into the left jugular vein 14 cc. of a fluid prepared by grinding up in a mortar a large number of young ticks in a small quantity of distilled water and filtering through filter paper. The ticks were hatched artificially from adults received

July 9, 12, and 19, from near New Berne, N. C. The hatching began August 9, 11, and 15, respectively. The injected fluid was turbid and grayish in color and passed through the filter with some difficulty.

(Ticks from lots received July 9 and 19 placed on the skin of No. 224 August 30 and September 3, produced Texas fever (see No. 224), showing that the ticks were capable of producing infection in the ordinary way.)

The condition of the blood on the the day of the injection was as follows: Red corpuscles, 6,228,500; white, 7,142. In fresh preparations a slight variation in size of the former and a few bright intraglobular bodies observed. Stained preparation negative.

September 9.—Temperature, 101.5; pulse, 72; respiration, 39. Red corpuscles, 6,050,000; white, 10,000. Nothing abnormal detected in preparations of fresh and stained blood.

September 21.—Temperature, 102.2. Red corpuscles, 5,666,000; white, 4,938. Nothing abnormal in dried and stained preparations of blood. (For temperature record, see p. 294.)

No. 203 (*native.*)—Cow, 6 years old, received June 20, from Charles County, Md., and placed in field between inclosures I and II until June 30. Then transferred to field VI for exposure to North Carolina cattle with ticks (North Carolina Cattle added July 1).

July 7.—Temperature, 102.5; pulse, 84; respiration, 48. Red corpuscles, 6,375,000; white, 10,000. In stained films slight variation in size of the red corpuscles. One corpuscle contains what appears to be a peripheral coccus.

July 12.—Temperature, 102.8; pulse, 80; respiration, 52. Red corpuscles, 5,800,000; white, 12,500. In stained preparation a slight variation in size of corpuscles. One intraglobular parasite (?) of irregular outline.

July 18.—Temperature, 102.4; pulse, 80; respiration, 52. Red corpuscles, 5,875,000; white, 13,750. In stained preparation a slight variation in the size of the red corpuscles.

August 22.—Temperature, 101.1; pulse, 108; respiration, 72. Red corpuscles, 1,659,000; white, 6,813. In the fresh blood about 2 to 3 per cent of the corpuscles appear infected with single parasites chiefly. There are besides a few bright intraglobular bodies, and a large number of very minute free diplococcus-like bodies not more than 0.2 to 0.3 μ in diameter in violent (Brownian?) motion. In stained preparation the irregular intraglobular parasites stain on the periphery only. Cow has continued eating until this morning; dies suddenly at 2 p. m. The very brief autopsy notes are appended to confirm the diagnosis.

Animals weighs about 500 pounds; in quite poor condition. A large number of ticks on udder and escutcheon, perhaps six to the square inch. Few on abdomen and dewlap. The ticks were of several sizes:

(1) Ticks within the last moult and about ready to emerge, 3.2mm ($\frac{1}{8}$ inch) long.

(2) Ticks just emerged from the last moult and quite active. Size as before.

(3) Adult ticks from 4 to 7mm. ($\frac{1}{6}$–$\frac{7}{25}$ inch) long.

(4) Males about 2mm. ($\frac{1}{12}$ inch) long.

Brain: Marked pigmentation and injection of the minute vessels of the pia on the hemispheres. A small hemorrhagic spot 3mm. in diameter in the third ventricle on left thalamus. The gray matter of cerebrum and cerebellum appears slightly reddened. Other changes absent.

The heart shows the usual epicardial and endocardial extravasations. Heart fibers show many fat granules.

The spleen weights $3\frac{5}{8}$ pounds. Large and softened. Markings no longer visible on section in the blackish pulp.

The liver weighs $13\frac{1}{16}$ pounds. Paler than normal and mottled on the surface. The cut surface is brownish yellow. Bile in gall bladder ($1\frac{1}{2}$ pounds) very thick and flaky. The kidneys weigh each $1\frac{1}{4}$ pounds, of the usual dark brownish red appearance. In the bladder 2 quarts of very dark port-wine colored urine barely translucent in a layer $\frac{3}{4}$ inch deep.

The mucosa of small intestine injected and coated with a pasty layer of desquamated epithelium. The cæcum contains soft feces and is extensively pigmented along the summits of the longitudinal folds.

In the serum expressed from the heart muscle a large number of pairs of parasites inclosed in barely visible bodies representing the outlines of former red corpuscles. In a teased preparation of spleen pulp several capillaries seen, plugged with infected corpuscles. In stained preparations the infection was roughly estimated as follows:

Spleen and liver about 10 per cent infected corpuscles.

Kidneys about 50 per cent infected corpuscles and many free forms.

Heart muscle about 30 per cent infected corpuscles and many apparently free forms. (For temperature record, see pp. 289, 290.)

No. 204 (native).—Bull, 2½ years old; received from Prince George County, Md., June 24, 1892, and placed in field between inclosures I and II until June 30. Then transferred to field XI.

August 26.—Temperature, 102.8. Red corpuscles, 5,540,000; white, 7936. Stained preparations show nothing abnormal. Transferred from field XI to field VI (North Carolina cattle with ticks) as control to reëxposed animals Nos. 56, 105, 135, 160, 166, 167, 182, 185.

September 8.—Temperature, 107.4; pulse, 72; respiration, 44. Red corpuscles, 4,225,000; white, 5,000. In the fresh blood a considerable number, perhaps 10 per cent, of very minute intraglobular bright bodies, of variable size, situated mainly near the periphery. A few are in motion. In stained preparations a few irregular intraglobular bodies of doubtful nature.

September 13.—Temperature, 103.5; pulse, 76; respiration, 28. Red corpuscles, 1,963,000; white, 1,219. Stained preparations show macrocytes.

September 27.—Temperature, 102; pulse, 60; respiration, 42. Red corpuscles, 3,753,000; white, 7,407. In fresh blood 30 to 40 per cent of the corpuscles are enlarged. Several bright bodies. In stained preparations no parasites detected.

October 10.—Temperature, 103.5; pulse, 64; respiration, 32. Red corpuscles, 5,012,000; white, 7,564. In stained preparations about 30 per cent macrocytes.

From September 10 to 15 the animal appeared decidedly sick. Appetite partly lost. It lay down much of the time and appeared gaunt and weak. Lately it has been improving rapidly. (For temperature record, see p. 290.)

No. 205 (*native*).—Grade Jersey cow, five years old; received June 30, 1892, from District of Columbia. Placed in Field II (North Carolina cattle without ticks). (North Carolina cattle added July 2.)

July 5.—Temperature, 103.8; pulse, 60; respiration, 64. Red corpuscles, 5,975,000; white, 6,250.

July 18.—Temperature, 102.8; pulse, 56; respiration, 48. Red corpuscles, 5,400,000; white, 6,250. Stained preparations show nothing abnormal.

August 25.—Temperature, 101; pulse, 60; respiration, 54. Red corpuscles, 5,962,500; white, 10,000. Slight variation in size of red corpuscles. A small number contain the bright bodies. Stained preparation negative.

September 2.—Temperature, 101.2; pulse, 54: respiration, 30. Red corpuscles, 5,887,500; white, 5,000. A small number of red corpuscles contain bright bodies. Stained preparation shows nothing abnormal.

September 16.—Temperature, 101.8; pulse, 48; respiration, 40. Red corpuscles, 5,370,000; white, 5,714. Nothing abnormal in stained preparation. (See p. 291.)

No. 206 (*native*).—Cow, seven years old; received June 30, 1892, from the District of Columbia and placed in Field III.

July 6, 9 a. m.—Received into left jugular vein 28 cc. (2 syringefuls) of blood drawn from left jugular of North Carolina cow No. 216. (See No. 198 for details of operation.) The following table gives the essential facts of the history of the disease induced by the injection.

No. 206 (native).

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature record, see pp. 292, 293.)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
July 5, 1892	6,662,500 (white, 8,750)	....	None	....	Normal	101.8	60	54	July 6. Intravenous injection of blood from North Carolina cow No. 216.
July 7, 1892	6,150,000 (white, 8,750)	....	......do	....	......do	101.8	56	48	
July 9, 1892	6,200,000 (white, 9,000)	....	......do	....	......do	101.8	60	30	
July 11, 1892	6,087,500 (white, 15,000)	....	......do	....	......do	102.2	60	48	
July 13, 1892	5,012,500 (white, 7,000)	....	Several paired parasites.	....	......do	105.2	60	64	Animal sick to-day. Head drooping and back slightly arched.
July 15, 1892	4,250,000 (white, 7,500)	....	5 per cent paired parasites.	....	......do	107.4	68	68	Losing flesh. Quite weak and dull. Appetite good.
July 16, 1892	4,062,500 (white, 10,000)	....	Very few paired parasites.	....	......do	104.6	78	44	
July 18, 1892	2,575,000 (white, 6,250)	....	A few large parasites.	....	A punctate cell.....	106.2	96	44	
July 20, 1892	1,975,000 (white, 7,500)	Many bright bodies.	None	10–15 per cent macrocytes.	A few punctate and tinted cells.	106.2	92	56	
July 22, 1892	1,575,000 (white, 5,000)	Some bright bodies .	......do	10–15 per cent macrocytes, one hæmatoblast.	3–4 per cent, punctate and tinted cells.	105.4	80	64	
July 25, 1892	1,841,000 (white, 9,090)	A few bright bodies.	......do	40–50 per cent macrocytes.	15–20 per cent tinted and a few punctate cells.	105.	72	88	
July 28, 1892	1,775,000 (white, 10,000)	Several large paired parasites.	About a dozen single and paired parasites.	20–25 per cent macrocytes.	A few punctate and tinted corpuscles.	106.2	88	80	Very little change in the outward appearance since July 15. Appetite has continued good.
Aug. 4, 1892	2,250,000	A few bright bodies.	None	40–50 per cent macrocytes.	Very few tinted and punctate cells.	103.1	64	52	Slight improvement during past week.

Aug. 9, 1892	3,064,500 (white, 4,839)	....	....	....	....	103.5	68	80	
Aug. 13, 1892	2,586,000 (white, 6,900)	5 per cent bright bodies.	....	Many macrocytes.	....	104.2	78	72	
Aug. 17, 1892	3,357,000 (white, 8,571)	Some bright bodies.	....	30–40 per cent macrocytes.	....	101.4	60	48	
Aug. 29, 1892	2,375,000 (white, 11,250)	....do	A few peripheral cocci.	Many macrocytes.	Several punctate cells.	105.2	60	78	
Aug. 30, 1892	....	A few bright bodies, some peripheral, pale bodies.	15–20 per cent peripheral cocci.	....do	A few tinted and punctate cells.	....	....	....	
Sept. 1, 1892	1,037,500 (white, 7,500)	....do	10 per cent peripheral cocci.	50 per cent macrocytes.	5 per cent punctate and tinted cells; one hæmatoblast.	103.0	105	42	
Sept. 3, 1892	....	....	....do	....do	....	102.6	84	42	
Sept. 6, 1892	1,175,000 (white, 7,500)	....	Fewer peripheral cocci.	Some haematoblasts; many macrocytes.	10 per cent punctate and tinted cells.	102.0	60	48	
Sept. 10, 1892	1,448,000 (white, 5,128)	5–10 per cent bright bodies.	2–3 per cent peripheral cocci?	Many macrocytes.	....do	....	....	....	
Sept. 14, 1892	1,447,000 (white, 2,353)	A few bright bodies.	A few peripheral cocci.	Corpuscles generally enlarged.	A few punctated and tinted cells; one haematoblast.	102.2	56	48	
Sept. 19, 1892	1,763,000 (white, 7,894)	....	5–10 per cent peripheral cocci.	....do	One punctate cell...	100.8	60	58	
Sept. 28, 1892	1,797,600 (white, 5,952)	Some pale peripheral bodies, 10 per cent bright bodies.	10 per cent peripheral cocci.	....do	Some punctate cells.	101.6	64	40	
Oct. 4, 1892	2,206,240 (white, 6,250)	A few bright bodies.	2–3 per cent peripheral cocci.	....do	....	102.0	56	30	Has been improving for some time past. The relapse noticed Aug. 29 has not shown itself by outward symptoms, excepting high evening temperature.

No. 207 (*native*).—Steer, 2 years old, received June 30, 1892, from Prince George County, Md., and placed in field XI.

August 31.—Transferred to field XIII.

Temperature, 103.2; pulse, 98; respiration, 78. (Animal much excited on being caught.) Red corpuscles, 5,985,700; white, 10,000. In preparations of fresh blood a moderate number of bright bodies detected. Nothing abnormal in stained preparation. The red corpuscles vary slightly in size.

Injected into left jugular vein 14 cc. of the same fluid used upon No. 202 (fluid from young ticks), with the exception that in this case the fluid was filtered through muslin instead of filter paper. The turbid filtered fluid held in suspension a considerable quantity of minute particles rapidly settling when the fluid was allowed to stand. (See also No. 224.)

September 9.—Temperature, 102.2. Red corpuscles, 5,275,000; white, 7,500.

In fresh and stained preparations nothing abnormal.

September 21.—Temperature, 102.4. Red corpuscles, 6,570,000; white, 6,024. In a stained preparation nothing abnormal. (For temperature record, see p. 294.)

No. 208 (*native*).—Cow, 5 years old, received June 30, 1892, from District of Columbia and placed in field I (North Carolina cattle without ticks. North Carolina cattle added July 2).

July 6.—Temperature, 102. Red corpuscles, 6,800,000; white, 7,500. Nothing abnormal in stained preparation.

July 15.—Temperature, 101.8. Red corpuscles, 5,811,000; white, 10,000. Stained preparation as before.

August 25.—Temperature, 101.2. Red corpuscles, 6,350,000; white, 11,250. Slight variation in size of red corpuscles. A few contain bright bodies. In stained preparation nothing abnormal.

September 2.—Temperature, 101.6. Red corpuscles, 5,500,000; white, 10,000. Slight variation in size of the former. Stained preparation as before.

September 16.—Temperature, 101. Red corpuscles, 6,080,000; white, 12,345. In stained preparation slight variation in size of the former. Otherwise nothing abnormal. (For temperature record, see p. 291.)

No. 209 (*native*).—Cow, 9 years old, received June 30, 1892, from the District of Columbia. Placed in field I (North Carolina cattle without ticks. North Carolina cattle added July 2).

July 6.—Temperature, 102.6. Red corpuscles, 6,787,500; white, 10,875.

July 15.—Temperature, 103. Red corpuscles, 6,000,000; white, 13,750.

July 25.—Temperature, 105.5. Red corpuscles, 5,675,000; white, 11,250. In a few red corpuscles bright bodies.

August 25.—Temperature, 102.8. Red corpuscles, 5,687,500; white, 10,000. Slight variation in size of the former. A few contain bright bodies.

September 2.—Temperature, 102. Red corpuscles, 5,225,000; white, 15,000. A few of the former contain bright bodies.

September 16.—Temperature, 100.6. Red corpuscles, 5,309,000; white, 8,333.

Stained preparations of blood collected on all of the above dates show nothing abnormal. In the last there is a very slight variation in size. (See p. 291.)

No. 210 (*native*).—Heifer, 2 years old, received June 30, 1892, from Prince George's County, Md.; placed in field I (North Carolina cattle without ticks. North Carolina cattle added July 2).

July 6.—Temperature, 102.2. Red corpuscles, 6,875,000; white, 16,625.

July 18.—Temperature, 102. Red corpuscles, 6,425,000; white, 10,000.

August 25.—Temperature, 102. Red corpuscles, 6,025,000; white, 12,500. Slight variation in size of the former. A few contain bright bodies.

September 2.—Temperature, 101.2. Red corpuscles, 5,650,000; white, 5,000. A few red corpuscles contain bright bodies.

September 16.—Temperature, 101.8. Red corpuscles, 6,076,000.

Stained coverglass preparations of blood collected at every one of the above dates show nothing abnormal after careful microscopic examination. (See p. 291.)

No. 212 (Southern).—Cow, 3 years old, received from near New Berne, N. C., July 1, 1892.

July 2.—Kept in a fenced-off portion of field VI over night. To-day ticks picked off, after which process the animal was placed in field I (North Carolina cattle without ticks).

July 3–27.—Animal examined daily and any ticks found carefully picked off. No ticks found after July 21.

No. 213 (Southern).—Cow, 5 years old. For source, removal of ticks, and field, see No. 212.

No. 214 (Southern).—Cow, 4 years old. For source of animal and removal of ticks see No. 212. Placed in field II July 2.

August 15.—Blood withdrawn from jugular to inoculate No. 222. Slight variation in the size of the red corpuscles (5 to 7μ.) No parasites detected in two stained preparations after prolonged search.

September 9.—Blood withdrawn to inoculate No. 230. No parasites detected in a stained preparation even after a long search.

No. 215 (Southern).—Cow, 4 years old. For source of animal and removal of ticks see No. 212. Placed in field II July 2.

No. 216 (Southern).—Cow, 6 years old, received from near New Berne, N. C., July 1, 1892, and placed in field VI (North Carolina cattle with ticks).

July 6.—Blood withdrawn from jugular vein to inoculate native No. 206.

July 14.—Red corpuscles, 6,050,000. In two stained preparations of blood, one peripheral coccus-like body detected after a long search.

July 16.—Blood withdrawn to inoculate native No. 219.

September 3.—Temperature, 102.8. Red corpuscles, 6,112,500; white, 15,000. In fresh preparations nothing abnormal. In a stained preparation nothing abnormal detected after a long search.

No. 217 (Southern).—Cow, 6 years old, received from near New Berne, N. C., July 1, 1892, and placed in field VI (North Carolina cattle with ticks).

July 6.—Bloood withdrawn from jugular vein to inoculate native No. 198.

July 8.—Red corpuscles, 6,012,500. In two stained preparations of blood, after a long search, a peripheral coccus detected in process of division.

September 3.—Temperature, 102.6. Red corpuscles, 6,600,000. Fresh preparations show nothing abnormal. In a stained preparation a pair of intraglobular pyriform bodies detected after a long search.

No. 218 (native).—Cow, 6 years old, received July 15, 1892, from Prince George County, Md., and placed in unused field XI.

July 16.—Temperature, 103. Red corpuscles, 6,450,000; white, 10,000. Transferred to field III, as control to inoculated cow No. 219.

August 4.—Temperature, 102.2. Red corpuscles, 5,437,500. In preparations of fresh blood about 10 per cent of all corpuscles contain bright motile bodies. August 6.—Temperature, 101.8. Red corpuscles, 6,342,000; white, 9,589. Condition of red corpuscles as on August 4. August 15.—Temperature, 102. Red corpuscles, 5,973,000; white, 10,666. Condition of corpuscles as before. August 29.—Temperature, 102.2. Red corpuscles, 6,587,500; white, 10,000. In fresh preparations 3 to 5 per cent of the former contain bright bodies. September 1.—Temperature, 101.8. Red corpuscles, 6,787,500; white, 8,750. Condition of the former as on August 29. September 17.—Temperature, 101.8. Red corpuscles, 5,820,000; white, 4,494. September 29.—Temperature, 101.5. Red corpuscles, 5,650,000; white, 10,000. From 2 to 3 per cent of the former contain bright bodies, varying in size.

Stained films of blood, prepared at every one of the above dates, show nothing abnormal after careful examination. (For temperature record, see pp. 292, 293.)

No. 219 (native).

Cow, 4 years old, received July 15, 1892, from the District of Columbia, and placed in unused field XI.

July 16.—Injected into left jugular 28 cc. (2 syringefuls) of blood drawn immediately before from right jugular of North Carolina cow No. 216 (for details see No. 198) and placed in field III with Nos. 198, 206, 218.

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature record, see pp. 292, 293.)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
July 16, 1892	6,325,000 (white, 11,250)	....	....	....	Normal	° 103.2	48	72	Intravenous injection of blood from North Carolina cow No. 216.
July 22, 1892	6,366,000 (white, 10,000)	A few bright bodies ..	....	Normal	....do	105.7	80	72	
July 23, 1892	6,700,000 (white, 10,000)	......do	One pyriform parasite.	....do	....do	105.1	60	84	
July 25, 1892	5,087,400 (white, 6.250)	{ ......do .... One large parasite.	....	....do	....do	107.2	68	108	Animal dull and eating but little.
July 26, 1892	4,325,000 (white, 5,000)	A few bright bodies...	One large parasite	....do	....do	107.2	72	104	
July 27, 1892	3,625,000 (white, 8,750)	{ ......do .... One pair large parasites.	....do	....do	....do	107.2	68	120	Losing flesh rapidly. Appetite entirely lost.
July 28, 1892	2,825,000 (white, 5,000)	{ Bright bodies increased Several large parasites.	....	....do	....do	106.8	72	88	
July 29, 1892	2,950,000 (white, 7,500)	{ A few bright bodies .. One large parasite.	One large parasite	....	....	105.2	72	88	Much emaciated. More active to-day.
July 30, 1892	3,037,500 (white, 6,250)	A few bright bodies ..	....	....	....	105.6	72	88	Appetite returning.
Aug. 2, 1892	2,850,000 (white, 12.000)	......do	Several large parasites.	20 per cent macrocytes.	....	103.8	68	64	Improving slowly.
Aug. 6, 1892	2,397,000 (white, 6 450)	Some large parasites..	....do	30–40 per cent macrocytes.	....	102.	72	68	Parasites in pairs, within macrocytes chiefly.

Aug. 10, 1892	2, 686, 700 (white, 9, 036)	A few large parasites.	....do	30 per cent macrocytes.	A few punctate and tinted cells.	102. 8	60	92	
Aug. 13, 1892	2, 806, 000 (white, 10, 448)	Native		30 per cent macrocytes and microcytes (4–4.5 μ).		103. 4	66	60	
Aug. 19. 1892	3, 693, 000 (white, 10, 666)	A few bright bodies..		30–35 per cent macrocytes.		102. 6	78	66	
Aug. 29, 1892	1, 725. 000 (white, 17. 500)	Some pale peripheral bodies.	30 per cent peripheral cocci.	......do	10 per cent punctate and tinted cells.	105.	84	66	Relapse first observed.
Aug. 30, 1892		......do	20–30 per cent peripheral cocci.	......do	......do				
Sept. 1, 1892	1, 294. 000 (white, 13, 000)	....do Some bright bodies. One pair large parasites.	15–20 per cent peripheral cocci.	Many macrocytes.	Many punctate and tinted cells.	103.	81	51	
Sept. 3, 1892			......do	......do	......do				
Sept. 6, 1892	1, 925. 000 (white, 8. 750)	A few bright bodies..	10–20 per cent peripheral cocci.	......do	Some punctate cells.	103. 6	69	32	
Sept. 10, 1892	1, 860. 000 (white, 6, 329)		5–10 per cent peripheral cocci; one large parasite.	......do	No punctate or tinted cells.	103. 1	66	60	
Sept. 14, 1892	1. 940, 000 (white, 6, 000)	A few bright bodies..	3–5 per cent peripheral cocci.	Corpuscles generally enlarged.		102. 5	60	36	
Sept. 19. 1892	1, 753. 000 (white, 11, 235)	......do	20 per cent peripheral cocci.	Some macrocytes .	Stained corpuscles absent.	103. 4	80	76	
Sept. 28, 1892	1, 682, 900 (white, 9, 756)	......do	15–20 per cent peripheral cocci.	......do	......do	102. 5	60	52	
Oct. 4, 1892	2, 329, 000 (white, 14, 634)	......do	5 per cent peripheral cocci.	......do	......do	103. 2	64	36	General condition not much changed since relapse. Animal quite thin.

No. 220 (*native*).—Steer, 2½ years old, received July 15, 1892, from Montgomery County, Md., and placed in an unused field XI.

July 20.—Transferred to field VI (North Carolina cattle with ticks). Temperature, 105.6 (elevated by prolonged chasing). Red corpuscles, 6,925,000; white, 12,500. In fresh preparations a few corpuscles containing bright bodies.

August 22.—Animal sick, eating but little.

August 24.—Temperature, 106.6; pulse, 105; respiration, 93. Red corpuscles, 2,727,000; white, 8,080. In fresh preparations one pair of large parasites and a few macrocytes.

August 25.—General condition slightly improved. Appetite returning.

August 27.—Temperature, 103.6; pulse, 84; respiration, 60. Red corpuscles, 2,550,000; white, 10,000. In fresh preparations parasites not detected. About 5 to 10 per cent macrocytes. In stained preparations a small number of macrocytes are feebly tinted or finely punctated.

September 1.—Temperature, 103; pulse, 108; respiration, 79 (animal excited). Red corpuscles, 3,662,500, white; 15,000. About 30 per cent macrocytes and a few bright bodies seen in fresh preparation. Macrocytes very large. A few feebly tinted and punctated corpuscles in stained preparation.

October 1.—Temperature, 101.5; pulse, 68; respiration, 36. Red corpuscles. 4,425,000; white, 12,500. Over 50 per cent macrocytes. This animal lost considerable flesh during the disease. Has been slowly gaining since the middle of September. (For temperature record, see pp. 289, 290.)

No. 221 (*native*).—Cow, 9 years old, received July 18, 1892, from Montgomery County, Md., and placed in unused field XI.

August 15.—Temperature, 102.4. Red corpuscles, 6,550,000. A moderate number contain bright bodies. Transferred to field III as control to inoculated case No. 222.

August 29.—Temperature, 102.4. Red corpuscles, 5,487,500; white, 10,000. Condition of blood as before.

September 1.—Temperature, 101.6. Red corpuscles, 5,912,500; white, 20,000. A few of the former contain bright bodies.

September 17.—Temperature, 102.5. Red corpuscles, 5,375,000; white. 10,000.

September 29.—Temperature, 101.8. Red corpuscles, 5,912,000; white, 9,876. A very few bright bodies in fresh preparation.

Stained films of blood prepared on each of the above dates show nothing abnormal. (For temperature record, see p. 293.)

No. 222 (*native*).—Steer, 5 years old, received July 20, 1892, from Montgomery County, Md., and placed in unused field XI.

August 15.—Received into left jugular vein 2 syringefuls, or 28 cubic centimeters, of blood drawn immediately before from jugular of North Carolina cow No. 214 (see No. 198) and placed in field III. The following table gives the subsequent history of this case and indicates a relapse first detected September 28.

No. 222 (native).

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature record, see p. 293.)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
Aug. 15, 1892	6, 125, 000 (white, 10, 000)	5–10 per cent bright bodies.	None	Normal	Normal	102. 6	60	60	Intravenous injection made to-day.
Aug. 22, 1892	5, 512, 500 (white, 10, 000)	Fewer bright bodies	One pair of pyriform bodies.	do	do	102. 2	54	60	
Aug. 25, 1892	4, 112, 500 (white, 7, 500)	Many bright bodies; Several large parasites	None	do	do	106. 6	78	108	
Aug. 27, 1892	3, 896, 000 (white, 7, 800)	Several large parasites; Fewer bright bodies	do	A few macrocytes.		106. 4	78	66	
Sept. 6, 1892	2, 862, 500 (white, 6, 250)	None	do	20–25 per cent macrocytes.		102. 2	72	48	
Sept. 17, 1892	2, 260, 000 (white, 8, 536)	A few bright bodies	do	30 per cent macrocytes.		102. 6	72	52	Appetite has been partly lost during fever. Some loss of flesh.
Sept. 28, 1892	2, 898, 700 (white, 8, 860)	Pale peripheral bodies numerous.	4–5 per cent peripheral cocci.	50 per cent macrocytes.		101. 6	72	56	Beginning of relapse.
Oct. 5, 1892	2, 031, 250	do	30 per cent peripheral cocci.	do		102. 8	80	40	
Oct. 11, 1892	1, 123, 450 (white, 9, 876)	A few bright bodies	20–30 per cent peripheral cocci.	50 per cent macrocytes. One hæmatoblast	20 per cent tinted and punctated corpuscles.	104. 5	88	68	
Oct. 18, 1892	2, 262, 500 (white, 7, 500)	One bright body	1 per cent peripheral cocci.	Over 50 per cent macrocytes.		104. 5	80	72	Has been improving slightly.

No. 223 (*native*).—Heifer, 6 years old, received July 20, 1892, from Montgomery County, Md., and placed in field VI (North Carolina cattle with ticks). Temperature, 102.5. Red corpuscles, 6,500,000; white, 10,000. In fresh preparations of blood a few corpuscles contained the bright bodies. Stained preparations negative.

August 19.—Temperature, 106.8; pulse, 72; respiration, 84. Red corpuscles, 5,087,500; white, 5,000. In fresh preparations of blood about 1 per cent of the corpuscles have a dark wrecked appearance, and contain the Texas fever parasite.

August 20.—Animal sick. Eating but little.

August 22.—Animal refuses food entirely.

August 23.—Animal died during the night.

Autopsy at 9 a. m.: Body in good condition as regards flesh. Weight about 600 pounds. A moderate number of ticks on inner aspect of thighs, escutcheon, and udder. The sizes are the same as those found on No. 203.

Both lungs quite full of blood. The left principal adherent to chest wall and the left ventral to the former by old connective tissue. Very marked extravasation of blood on the base of the heart, extending about 2 inches each side of the interventricular groove. Slight ecchymosis beneath endocardium. Injection of heart muscle. Cloudy and fatty changes of fibers.

Spleen weighs 4¼ pounds. Capsule much distended. Pulp blackish, but still firm and markings effaced.

Liver weighs 14⅜ pounds. It is of a uniform yellowish-brown color, as viewed from the exterior, excepting near the left border, where there is more or less grayish mottling. More or less bile injection in circumscribed areas detected in sections of fresh tissue. The gall bladder contains 4 ounces of bile, having a dark yellowish-green color, and holding a very large quantity of flaky material in suspension.

The fat surrounding kidneys infiltrated with reddish serum. With capsule removed each weighs 1⅜ pounds. The parenchyma has the usual dark brownish-red granular appearance of the cut surface. Slight ecchymosis of the calices of the pelvis. In sections of fresh tissue marked injection of all capillaries. In the bladder about 2 quarts of port-wine colored urine slightly more translucent than that of No. 203.

Digestive tract: In the fourth stomach the mucosa of laminated portion shows a large number of round whitish spots, not elevated above the general surface, 2 to 5 mm. in diameter. (*Strongylus Ostertagi?*) The epithelium over these spots intact. In pyloric portion two or three small blackish depressed scars. In the small intestine the mucosa is injected as usual, and covered with a thin grayish pasty layer composed entirely of desquamated epithelium. There is much bile in the intestine. In sections of the fresh mucosa, the parasites of Texas fever can be seen distinctly in every corpuscle of some of the distended capillaries.

Uterus contains a fœtus 7 to 8 inches long. Amniotic fluid free from hæmoglobin.

The pia covering the hemispheres of the brain injected and pigmented. The brain substance and the ventricles show no lesions excepting a more pinkish appearance of the gray matter of the cerebellum.

In the organs the number of infected corpuscles, estimated from stained cover-glass preparations, is approximately as follows:

Spleen, 10 per cent, parasites single and in pairs.

Liver, 30 per cent, parasites chiefly in pairs.

Kidney, 30 per cent, together with a very large number of free forms.

Heart muscle, 30 per cent, and many free pairs. (For temperature, see pp. 289, 290.)

No. 224 (*native*).—Cow, 11 years old, received August 1, 1892, from Prince George County, Md., and placed in field XI.

August 4.—Temperature, 103.8; pulse, 68; respiration, 76 (excited in being caught). Red corpuscles, 6,194,000. No abnormal appearances in fresh and stained preparations.

August 9.—Placed in box stall to-day, and the artificially hatched young ticks of *Amblyomma unipunctata* placed on neck and rump.

August 30.—The ticks have not developed. A large number of artificially hatched ticks of *Boöphilus bovis* placed on rump and neck. Adults of these ticks received from near New Berne, N. C., July 19, 1892. The young began to hatch August 15.

The condition of the blood to-day is as follows: Red corpuscles, 6,112,500; white, 7,500. A few corpuscles contain bright bodies. In stained preparation nothing abnormal.

September 3.—A second lot of young ticks (*B. bovis*) placed on animal. Adults were received July 9. The young began to hatch August 9. (See also Nos. 202 and 207.)

September 10.—Temperature, 106.8; pulse, 72; respiration, 24. Red corpuscles, 3,925,000; white, 5,000. In a stained preparation two corpuscles found containing large parasites.

September 15-20.—Animal has lost considerable flesh. Dull.

September 22.—First matured ticks found.

September 26.—Temperature, 102; pulse, 80; respiration, 24. Red corpuscles, 2,062,500; white, 5,000. From 25 to 30 per cent macrocytes and a very few punctate corpuscles. A large number of ticks almost ready to drop off on this animal.

September 29.—Very little improvement; animal thin and weak, probably in part due to the abstraction of blood by the many maturing ticks.

No. 225 (native).—Cow, 8 years old, received August 1, 1892, from Prince George County, Md. Placed in field XI.

August 2.—Transferred to box stall in stable. A few young recently hatched ticks placed on rump and neck. Temperature, 102.2. Red corpuscles, 6,405,000; white, 9,459. A few bright bodies in corpuscles. Stained preparation negative.

August 10.—This process of adding young ticks repeated daily from August 2 until to-day. The adult ticks were collected near New Berne, N. C., June 27, from Hyde County cattle. Eggs laid June 29-July 11. The young began to appear July 30.

August 15.—Refuses food.

August 17.—Losing flesh rapidly. Temperature, 105.8; pulse, 72; respiration, 42. Red corpuscles, 4,800,000; white, 10,750. One large parasite detected in fresh blood after some searching. In stained preparation 10 to 12 corpuscles detected containing pyriform bodies.

August 18.—Feces passed in small quantity and deeply bile-stained. Animal weak and lying down much of the time. Urine appears free from coloring matter of the blood.

August 19.—Very weak. Urine as yesterday. Feces soft. Drinking much water, but refusing solid food.

August 24.—Has been slowly improving since August 21. Appetite returned. Ticks beginning to mature. Temperature, 102; pulse, 75; respiration, 51. Red corpuscles, 2,987,000; white, 8,860. Macrocytes 10 to 15 per cent. One hæmatoblast seen. A few punctate macrocytes in stained preparation.

August 30.—A large number of ticks have matured since August 24 and many are still maturing. Animal improving. Transferred from stable to field VI (North Carolina cattle with ticks).

September 5.—Temperature, 101.7; pulse, 63; respiration, 39. Red corpuscles, 4,600,000; white, 10,000. A few bright bodies seen in fresh blood. Twenty per cent macrocytes.

September 23.—Temperature, 102.7; pulse, 80; respiration, 52. Red corpuscles, 1,888,000; white, 7,407. A few pairs of large parasites detected in fresh and stained blood. Ten to 15 per cent macrocytes up to 11 μ in diameter. Some punctated and tainted. Several hæmatoblasts.

October 1.—Temperature, 102.2; pulse, 60; respiration, 24. Red corpuscles, 3,300,000; white, 1,111. Macrocytes over 50 per cent (8 to 10 μ in diameter).

October 10.—Temperature, 102.7; pulse, 68; respiration, 36. Red corpuscles, 3,623,000; white, 4,706. Macrocytes still numerous. Animal still thin. Slowly improving. (For the temperature record, see p. 290.)

No. 227 (*native*).—Cow, 11 years old, received August 27, 1892, from the District of Columbia. Received, on this day, under the skin of the neck, with a hypodermic syringe, 2 cc. of defibrinated blood from sick native (No. 222). The injection was made in four places, ½ cc. being injected in each place. Animal placed in fenced-off portion of field XII (XII_a.) (For the preparation of the blood and other details, see No. 197.)

August 30.—Temperature, 102.2; pulse, 60; respiration, 72. Red corpuscles, 5,312,500; white, 5,000. A few corpuscles contain bright bodies.

September 5.—Temperature, 105.4; pulse, 78; respiration, 66. Red corpuscles, 3,887,500; white, 3,750. A few corpuscles contain large parasites.

September 6.—Animal weak and eating but little.

September 8.—Animal very weak; stands with head drooping; hind quarters sway in walking; refuses food entirely.

September 9.—Temperature, 101.5; pulse, 84; respiration, 12. Red corpuscles, 1,555,000; white, 6,666. A few enlarged corpuscles detected.

Dies about 6 p. m. to-day.

September 10, 10 a. m.—*Autopsy:* Cow now weighs about 500 pounds; weight before disease, 750 to 800 pounds. Fat over the entire body of a deeper yellow than is found in cows of this age. Slight post-mortem decomposition.

Extensive ecchymoses beneath epicardium and endocardium of ventricular surfaces of heart. In both cavities small firm clots, having on the surface a bright golden color in patches.

Lungs full of blood, collapsed only in part. Old fibrous adhesions to chest wall. Slight interlobular emphysema.

Spleen very large and of the usual blackish appearance on section. Much pigment in large lumps detected in teased preparations. Also many large red corpuscles and some hæmatoblasts. Liver shows a uniform yellowish color throughout. In fresh sections, the parenchyma found in state of complete fatty degeneration. Individual cells contain 2 to 4 oil globules larger than red corpuscles. Occasional patches of bile injection. Bile viscid and loaded with flocculent matter, which stains the hands intensely yellow.

Kidneys surrounded by reddish œdematous tissue. Parenchyma pale. On section there is a swollen œdematous appearance with absence of the usual markings. The base of the pyramids marked with pale striæ. In fresh sections these correspond to tubules completely filled with fat globules. Clumps of amorphous yellow pigment are scattered through the epithelium of the straight tubules and bundles of needle-like yellowish crystals 4 to 8 μ long are also present. Urine free from hæmoglobin, rather yellowish in color. Albumen present in very small quantity.

In stained preparations of the various organs many large bacilli (post-mortem) detected. There are present perhaps ten per cent of quite large macrocytes which have retained a very feeble stain. The intraglobular parasites are quite scarce. In the preparations of liver and the heart muscle, about one-half to one per cent of the red corpuscles contain single or paired pyriform bodies. In the spleen and the kidney preparations none are found. (For the temperature record, see p. 294.)

No. 228 (*native*).—Cow, 7 years old, received August 27, 1892, from the District of Columbia. Received under the skin of the neck 1 cc. of defibrinated blood from sick native No. 222. The injection was made in two places, ½ cc. being injected at a time (see No. 197 for preparation of blood and other details). Placed in fenced-off portion of field XII. The blood examined before the inoculation gave the following figures: Red corpuscles, 5,948,700; white, 9,874. In preparations of fresh blood 2 or

3 per cent of all corpuscles contain bright bodies varying in size from mere points to $\frac{1}{2}$ μ. in diameter. In stained preparation nothing abnormal.

September 5.—Temperature, 106. Red corpuscles, 4,586,900; white, 5434. In fresh preparations of blood 2 to 3 per cent of corpuscles found with large Texas fever parasites and a few with bright bodies. One stained preparation negative.

September 6.—Eating very little.

September 7.—Appetite entirely gone.

September 9.—Temperature, 105.8. Red corpuscles, 3,185,700; white, 10,000. In fresh preparations nothing abnormal detected. In stained preparation several corpuscles containing large pyriform parasites.

September 10.—Animal weak. Stands with head drooping. Hind quarters sway in walking. Has grown thin.

September 14.—Temperature, 102.1. Red corpuscles, 1,512,200; white, 1087. In fresh preparations a few corpuscles with bright bodies. Fully 10 per cent are macrocytes. Of these a very few are found punctate and tinted in stained preparation.

September 26.—Temperature, 101.2; pulse, 48; respiration, 12. Red corpuscles, 2,757,000; white, 11,428. Fully 60 per cent macrocytes present, of which 10 per cent are finely punctated or tinted in stained preparation. The animal is improving slowly.

October 8.—Still very thin and weak, although appetite good.

October 27.—Temperature, 102.6; pulse, 60; respiration, 24. Red corpuscles, 3,300,000; white, 11,250. In fresh preparations 1 to 2 per cent bright bodies within corpuscles. In stained preparation 5 to 10 per cent of the red corpuscles are infected with the peripheral coccus-like bodies. (For the temperature record, see p. 294.)

No. 230 (*native*).—Cow, 9 years old, received September 7, 1892, from the District of Columbia, and placed in unused field XI.

September 9.—After the examination of the blood, this animal received into the left jugular vein 28 cubic centimeters (two syringefuls) of blood, drawn immediately before from the left jugular vein of North Carolina cow No. 214. Transferred to field III, now containing Nos. 206, 218, 219, 221, and 222 (see No. 198 for details of the operation). The following table indicates an acute attack followed by a relapse:

No. 230 (native).

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.		Temperature.	Pulse.	Respiration.	Remarks. (For temperature record, see page 293.)
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.				
Sept. 9, 1892	5, 700, 000 (white, 10, 000)	One bright body	None	Normal	Normal	103	60	40	Intravenous injection made to-day.
Sept. 17, 1892	3, 939, 000	About 1 per cent large paired parasites.		do	do	105. 5	64	52	Some slight illness and loss of flesh noticeable.
Sept. 23, 1892	2, 987, 800 (white, 7, 304)	One pair large parasites.	None	do	do	105. 5	60	20	
Oct. 1, 1892	2, 269, 000 (white, 15, 476)	None	do	Some macrocytes		101. 2	60	32	
Oct. 11, 1892	2, 415, 500 (white, 6, 493)	do	2–3 per cent peripheral cocci.	50 per cent macrocytes.		103	58	36	Beginning of relapse.
Oct. 18, 1892	2, 212, 500 (white, 6, 250)	A few bright bodies.	10 per cent peripheral cocci.	do		102. 8	60	28	Quite thin and weak.
Oct. 25, 1892	1, 837, 500 (white, 8, 750)	do				102. 5	84	20	
Oct. 29, 1892	1, 142, 800 (white, 13, 000)	Some pale peripheral bodies.				100. 5	68	20	

TEMPERATURE RECORD OF THE VARIOUS ANIMALS USED IN THE EXPERIMENTS FROM 1889 TO 1892, INCLUSIVE.

The following tables include with but three exceptions (Nos. 158, 166, and 180) the temperature record, in degrees and tenths of degrees Fahrenheit, of all cattle used in the field experiments at the Washington station. The temperature of the three cases noted as exceptions was not taken regularly, and hence the only record forthcoming is that printed with the notes under each case.

In consulting these tables the reader may find what appear to be discrepances between the temperature as given here and that already printed with the notes under each case. This apparent discrepancy is due to the fact that the temperature as given in the tables and as tabulated with the blood examination was, as a rule, taken at different hours of the same day or on different days. Hence, in case of considerable daily fluctuation, such as is usually the rule, at least in hot weather, in mild attacks and relapses and at the beginning and at the end of the acute attacks, these two records may not agree closely.

The hour in which the temperature was taken is given in the tables. Slight fluctuations in healthy animals may here and there be explained by taking into account the time of day since there is a slight rise of temperature towards evening.* The hour of the blood examination is not given in the notes of the individual cases, but it was made, with few exceptions, before noon.

The record of the same animal exposed for several successive seasons is given in a separate table for each fresh exposure. The pages on which such records may be found are given at the end of the notes for each case or with the remarks, if the notes have been tabulated.

The daily fluctuations associated with the beginning of the fever, and quite marked in some cases may be studied in tables on pages 276, 284, 285, 288, 291, 292, 293, 294, and 295, where the morning and evening temperature is recorded.

The temperature of Southern animals used as sources of infection in the various inclosures was not taken. Whenever such animals were exposed on subsequent occasions, for the purpose of determining any loss of immunity, their temperature was recorded. The record of such cases and of a few natives which remained healthy during the period of exposure (page 291, and elsewhere) furnishes a valuable basis of comparison with the record of the actually diseased animals.

* See pages 16, 17, and 151.

Field I, 1889.

Number of animal	7	8	9	10	11	75	46	43	44
Age of animal	6 years.	18 months.	18 months.	4 months.	4 months.	4 months.	20 months.	3 years.	4 years.
Date of exposure	June 27.	June 27.	June 27.	June 27.	June 27.	June 27.	Aug. 20.	Aug. 24.	Aug. 24.
Result of exposure	Died.	Died.	Died.	Died.	Died.	Recovered.	Died.	Died.	Died.
Died, days after exposure	57	61	65	65	75		21	20	24
June 29, 9 a. m	101.2	101.8	102	103	102.5	102.6			
July 5, 9 a. m	101.8	101.6	102.8	105.6	102.5	102.6			
July 6, 9 a. m	101.8	101.6	106.5	105.4	103.5	102.5			
July 7, 9 a. m	101	100.6	105.6	102.4	104.4	101.7			
July 8, 8.30	101.5	102.5	105.4	102.2	102.4	102			
July 9, 9 a. m	102.2	105.5	103.2	102.5	102.1	102.4			
July 10, 8 a. m	101.2	102.1	101.1	101.5	101.5	101.7			
July 11, 8.30 a. m	101.9	101.8	101.7	101.7	101.7	101.8			
July 13, 8.30	101.2	101.5	102.2	102.1	102	102			
July 15, 10 a. m	101.2	101.6	102	102.7	102.6	101.5			
July 17, 8.30	101.2	100.8	101.1	104.7	101.9	101			
July 19, 10 a. m	102.7	101.5	101.9	102.8	102.7	102.3			
July 23, 10 a. m	102.3	101.9	102.6	102.5	102.8	102.1			
July 27, 10 a. m	101.3	102.1	101.9	101.2	103	102.1			
July 29, 10 a. m	101.4	102.1	102.5	103.2	102.3	102.9			
Aug. 1, 10 a. m	101.7	101.9	103.5	102.9	102.1	102			
Aug. 2, 10 a. m	101.8	101.9	104.1	103.5	103.1	102.5			
Aug. 3, 10:30 a. m	101.7	101.3	102.5	102.3	101.9	101.7			
Aug. 5, 9:30 a. m	100.6	101.5	102.2	101.3	101.1	100.9			
Aug. 6, 10 a. m	101.5	101.9	102.5	103.1	101.6	101.2			
Aug. 7, 10 a. m	101.6	101.9	102.4	102.7	102.4	102.2			
Aug. 8, 10 a. m	101.7	102.1	102.5	102.7	102.6	101.9			
Aug. 9, 10 a. m	101.1	101.7	102.5	101.7	101.6	101.7			
Aug. 10, 10 a. m	101.1	101.8	101.9	101.9	101.4	101.3			
Aug. 12, 9:30 a. m	101.5	102.1	101.9	103.9	102.9	102			
Aug. 15, 3 p. m	101.8	101.7	106.7	102.8	102.4	102			
Aug. 16, 2:30 p. m	102.1	101.7	104.1	102.5	103.9	102.4			
Aug. 17, 10 a. m	106.9	102	104.9	103.1	104.6	101.4			
Aug. 18, 10 a. m	106.9	101.7	104.1	102.8	102.7	103.1			
Aug. 19, 10 a. m	107.4	101.9	102.2	103.2	104.3	102			
Aug. 20, 9:30 a. m	106.5	101.6	102.1	103.1	101.7	101.8			
Aug. 21, 11 a. m	105.5	101.9	103.3	103.7	104.1	104.5	103.3		
Aug. 22, 12 m	106	102.1	104.9	104.4	104.9	103	103.7		
Aug. 23, 3 p. m	Dead	103.4	105	103.5	102.8	102	102.5		
Aug. 24, 10 a. m		103.2	105.2	104.1	103.2	103.8	103.1		
Aug. 26, 11 a. m		103.7	105.2	103.4	103.9	102.2	102.5	103.2	102.3
Aug. 27, 4 p. m		99.8	106.1						
Aug. 28, 10 a. m		Dead	105.4	102.9	104.2	102.7	102.3	103.4	102.6
Aug. 29, 9 a. m			106						
Aug. 30, 11 a. m			105.8	102.9	103	104.2	102.5	103.4	102.5
Aug. 31			Dead	Dead	104	104.4	105	105.3	103.5

Field I, 1889—Continued.

Number of animal	11	75	46	43	44	53	54	57	70	71
Age of animal	4 months.	4 months.	20 months.	3 years.	4 years.	1½ years.	2 years.	9 years.	2½ years.	3½ years.
Date of exposure	June 27.	June 27.	Aug. 20.	Aug. 24.	Aug. 24.	Sept. 6.	Sept. 6.	Sept. 14.	Sept. 30.	Oct. 19.
Result of exposure	Died.	Recovered.	Died.	Died.	Died.	Recovered.	Died.	Negative.	Died.	Negative.
Died, days after exposure	75		21	20	24		14		19	
Sept. 2, 3 p. m	101.8	103.7	106.2	105.2	102.3					
Sept. 3, 3:30 p. m	104.1	104	107	104.3	103.2					
Sept. 4, 9 a. m	102.2	104.3	106.6	102.7	102.6					
Sept. 5, 11 a. m	102.1	102.2	107.3	104.2	102					
Sept. 6, 10:30 a. m	103.9	104.9	106.8	105.9	103.6	103.5	104			
Sept. 7, 9:30 a. m	102.9	102.5	106.4	107.4	104.1	102.6	101.2			
Sept. 9. 9 a. m	101.6	101.9	105.4	106	104.5	102.4	102.7			
Sept. 10, 3:30 p. m	Dead.	103.6	96.2	107.2	105.8	102.7	102.9			
Sept. 11, 4 p. m		102.8	Dead.	106.8	106.1	102.1	102.1			
Sept. 12, 4 p. m		101		103.6	106.2	102.7	102.5			
Sept. 13, 2 p. m		103.1		Dead.	106.7	104.3	102.2			
Sept. 14, 3 p. m		105			107.2	103.1	103.2			
Sept. 16, 12 m		105.2			103.1	103.5	105.6			
Sept. 17, 3 p. m		102.5			Dead.	102	107			
Sept. 18, 12 m		103.2				102.2	107.2	101.8		
Sept. 20, 8:30 a. m							101.2			
Sept. 22, 11 a. m		102				104.5	Dead.	100.7		
Sept. 24, 7 a. m		101.4				101		100.2		
Sept. 26, 9:30 a. m		104.2				101		101.2		
Sept. 27, 11:30 a. m		103				105		102		
Sept. 28, 2 p. m		103.1				105.2		101.4		
Sept. 30, 2 p. m		102				105.8		101.7	101.6	
Oct. 1, 11:30 a. m		103.9				106		101.8	101.2	
Oct. 2, 10 a. m		99.9				103.9		101.2	101.1	
Oct. 3, 11:30 a. m		101.7				103.9		100.5	101.6	
Oct. 4. 2 p. m		104.7				101.2		101.6	101.1	
Oct. 5, 2 p. m		103.2				103.2		101.5	101.9	
Oct. 7, 10:30 a. m		101.5				102.2		102.3	102	
Oct. 10, 2 p. m						102.9				
Oct. 17, 11:30 a. m		103.9				103		102.9	106.8	
Oct. 18, 12 m									107.2	
Oct. 19, 7 a. m									102.8	
Oct. 22, 2:30 p. m						102.5		101.2	Dead.	102
Oct. 24, 12:30 a. m						103.3		100.7		102.1
Oct. 26, 8:30 a. m						101.2		101.4		101.1
Oct. 29, 3:30 p. m						102		101.2		101.3
Oct. 31, 1 p. m		102.5				102.2		101.4		101.6
Nov. 2, 2:30 p. m		103				103.4		101.6		101.4
Nov. 4, 11:30 a. m		103				104.8		101.8		101.7
Nov. 6, 4 p. m		103				106.4		103.4		102
Nov. 11, 3:30 p. m		103				102		101.4		101.4

Fields II and III, 1889.

No. of animal	51	52	53	54	56	47	49	35
Age of animal	3 years	4 months	1½ years	2 years	2½ years	3½ years	3 years	2 years.
No. of field	II	II	II	II	II	III	III	III.
Date of exposure	June 27 and Sept. 14	June 27 and Sept. 14	June 27	June 27	Sept. 14	Sept. 14	Sept. 14	Sept. 14.
Result of exposure	Recovered.	Recovered.	Negative.	Negative.	Negative.	Recovered.	Negative.	Negative.
Aug. 22, 4 p. m	102.5		103.9	103				
Aug. 23, 4 p. m	102.1	102.1	102.2	102.3				
Aug. 24, 11 a. m	103.6	103.4	102.9	103				
Aug. 26, 11 a. m	102.5	102.4	102	102.7				
Aug. 28, 11 a. m	102.3	102.5	101.9	101.9				
Aug. 30, 12 m	102.7	102.7	102.3	102.9				
Aug. 31	102.1	102.9	101.8	102.8				
Sept. 2, 3 p. m	102.5	103.5	101.5	102.2				
Sept. 3, 3:30 p. m	102.6	102.7	102.3	102.2				
Sept. 6, 10 a. m	103.4	103.8	(*)	(*)				
Sept. 26, 9:30 a. m	102.7	103.6			102.9	102.6		
Sept. 27, 11.30	101.6	103.2			102			
Sept. 28, 9:30	101.4	103			101.2	102	101.9	101.3
Sept. 30, 1:30 p. m	102	102.6			101.7	101.8	101.6	101.6
Oct. 1, 1 p. m	103.9	103.1			103	101.9	103.8	102.8
Oct. 2, 12 m	103	102			101.9	101.1	102	101.2
Oct. 3, 11:30 a. m	101.2	101.2			101.3	101.7	101	102.1
Oct. 4, 2:30 p. m	102	102.9			102.5	101.8	102.2	102.1
Oct. 5, 2:30 p. m	102.3	102			101.9	101.3	101.7	101.5
Oct. 7, 10:30 a. m	101.6	102			101.9	101.1	102.3	101.8
Oct. 22, 2:30 p. m	104.2				102	103.4	101.6	101.3
Oct. 24, 11:30 a. m	102.7				101.8	101.4	102	103
Oct. 26, 8:30 a. m	103.6				101.9	103	103.8	101.6
Oct. 29, 3:30 p. m	104.1	104.6			101.6	101.2	102	103
Oct. 31, 1 p. m	104.7	105			101.1	101.3	102.3	102.6
Nov. 2, 2:30 p. m	103.5	104.1			102	102.1	102.2	102.9
Nov. 4, 11:30 a. m	102.4	105.7			102.7	102.2	102	103
Nov. 6, 4 p. m	104	106.6			102.7	102.2	102.4	102.6
Nov. 11, 3.30 p. m	101.8	101.7			101	104	101.6	101.8
Nov. 15						100.5		
Nov. 16						101		

* Transferred to field I.

Fields IV and V, 1889.

No. of animal	41	50	66	97	64	65	83	48
Age of animals	4 years	3 years	1½ years	2 months	2½ years	2½ years	2 months	2 years.
No. of field	IV	IV	IV	IV	V	V	V	V.
Date of exposure	Sept. 14	Sept. 14	Sept 14	Sept. 14	Sept. 14	Sept. 14	Sept. 14	Sept. 14.
Result of exposure	Negative	Negative	Negative	Negative	Recovered	Recovered	Negative	Died.
Sept. 26, 9:30 a. m	101.8	101.7	102.6	103.7				
Sept. 27, 11:30 a. m					102.6	102.4	103.1	101.1
Sept, 28, 12 m	102.6	101.9	102.7	103.1	100.9	101.9	103	101.2
Sept. 30, 1 p. m	101.1	101.7	101.5	102.2	101.1	101.7	102.4	101.6
Oct. 1, 1 p. m	104	101.9	102.8	104	102.4	101.9	102	100.8
Oct. 2, 12 m	101	101.5	101.9	102	101.7	102.5	101.5	101.3
Oct. 3, 11:30 a. m	101.2	101.3	101.7	102.7	102	103	102.6	101
Oct. 4, 2:30 p. m	101.6	101.8	102	103.1	101.8	104.1	101.9	101.1
Oct. 5, 3 p. m	102.2	101.7	102.1	102	102	104.3	103.2	102
Oct. 7, 10:30 a. m	101.1	101	101.2	102	102.5	102.5	102.4	101.2
Oct. 20, 5 p. m					102.5			104.5
Oct. 21, 8:30 a. m								99.5
Oct. 22, 3 p. m	101.8	101.8	101.6		102.1	102.6	103	Dead.
Oct. 24, 11:30 a. m	101.6	101.6	101.7		101.2	101.3		
Oct. 26, 8:30 a. m	101.4	101.5	101.6		101.2	101.5		
Oct. 29, 3:30 p. m	101.6	101.8	101.8	101.6	101.2	104.7	103.1	
Oct. 31, 1 p. m	102	101.1	101.8	102.6	101.5	101.6	101.9	
Nov. 2, 2:30 p. m	105.1*	101.4	102	102.6	102.3	103.2	103	
Nov. 4, 11:30 a. m	104.2	101.1	102	103	102.4	102	102.2	
Nov. 6, 4 p. m	103.2	102.8	102.5	103	102.2	101.8	103.2	
Nov. 11, 3:30 p. m	102.1	101.5	101.8	102	101.7	101.6	102.8	

* No. 41 suffering from a severe cold.

Fields I and II, 1890.

No. of animal	74	91	130	80	82	107	128	129	139	111	97	142	143	62
Age of animal	2 years	3 years	5 years	7 years	5 weeks	1 year	Old	2 years	6 years	1½ years	1 year	1½ years	1½ years	2 years
No. of field	I and II	I	I	II	II	II	II	II	II	I	I	I	I	II
Date of exposure	May 26 and Sep. 25	May 26	July 9	July 5	July 5	July 5	July 4	July 5	Aug. 30	Sept. 1	Aug. 25	Sept. 16	Sept. 16	Sept. 25
Result of exposure	Died	Negative	Negative	Died	Died	Recovered	Died	Died	Died	Died	Negative	Slightly affected	Negative	Negative
Died, days after exposure	21			54	154		59	55	14	107				
July 5, noon	101.2	100.9		101.3	102.7	103.6	100.8	102.3						
July 7, 4 p.m	102.8	102.8		102.7	103.2	103	102.8	101.8						
July 8, 6 p.m	102.9	104.2		102.6	103.7	103.7	103.4	101.8						
July 9, 9 a.m	101	101.2	101.6	102.8	102.8	103.	101	102.5						
July 9, 6 p.m	102.2	103.2	102.6											
July 11, 9 a.m	100.8	100.9	101	101	101.8	101.5	100.2	100.2						
July 12, 10 a.m	101	100	100.4	101.2	101.8	101.6	100.8	101.3						
July 14, 10 a.m	100.6	100.5	100.6	100.6	101.8	101.6	100.4	100.8						
July 16, 9 a.m	101.2	101.4	101.8	102.2	102.6	102	100.8	101.6						
July 18, 9 a.m	100.8	100.8	101.8	101.4	102	102.4	100.8	102						
July 19, 9 a.m	99.8	100.8	101.2	100.8	101.8	101.2	101	101						
July 21, 10 a.m	100.5	100.5	101	101	101.8	101.2	101.6	101.4						
July 22, 9 a.m	100.5	100.6	101	100.8	101.2	100.7	100.6	101						
July 23, 9 a.m	100.5	100.4	101.2	100.8	101.8	101.2	101.2	100.6						
July 25, noon	100.6	100.6	101	100.8	101.9	100.4	100	100.7						
July 26, 11 a.m	101.2	101.4	101.6	100.7	103	101	101.4	100.8						
July 28, 11 a.m	100.8	100.6	101.2	102.2	101.6	101	100.2	100.8						
July 30, 10 a.m	101.4	100.7	100.8	103	101.6	102	100.6	101.3						
Aug. 1, 9 a.m	100.8	101	101.1	105.1	102.1	102.4	103	101.8						
Aug. 2, 10 a.m	100.8	101	101.2	102.5	102.2	101.1	101.8	101.2						
Aug. 4, 9 a.m	100.6	100.2	100.8	101.4	101.2	101.2	101.8	101						
Aug. 6, 10 a.m	100.8	100.7	101.4	100.8	101.5	101	102.8	101.2						
Aug. 8, 10 a.m	101.2	100.5	101	100.6	101.6	100.7	100.8	101						
Aug. 9, 10 a.m	101.5	101.2	101	100.8	101.4	101.5	101.8	101.4						
Aug. 11, 10 a.m	100.2	100.5	100.6	100.1	101.2	101.4	100.2	100.8						
Aug. 13, 10 a.m	100.6	101	101	100.7	100.7	100.8	100.6	100.5						
Aug. 15, 10 a.m	100.6	101	101	101.2	101.7	102	101.8	102						
Aug. 16, 10 a.m	100.7	100.6	100.8	100.2	101.6	100.8	100.7	100.6						
Aug. 18, 2 p.m	100.8	101	101.3	101	102	102.1	101.2	101.2						
Aug. 19, 10 a.m	101.5	101.6	101.9	101.4	102.2	101.6	102.2	101 3						
Aug. 21, 10 a.m	100.7	100.8	100.6	100.8	101.8	101.4	100.7	100.4						
Aug. 23, 10 a.m	100.3	100.2	100.5	101.6	102	104.8	100.1	100.5						
Aug. 25, 10 a.m	99.2	100.1	100.3	106.2	102.3	104.5	100.2	106						
Aug. 27, 10 a.m	100	100.8	100.8	106	103.1	104.2	101.5	106.6			100.5			
Aug. 29, 10 a.m	100.2	100.6	100.8	Dead.	103	104.6	104.7	101.2			100.7			
Aug. 30, 10 a.m	100.8	100.8	101		102	103.4	105	Dead.			101.2			
Sept. 1, 10 a.m	100.2	100	100.7		102.3	102.2	98		100.5	100.8	100.4			

Fields I and II, 1890—Continued.

No. of animal	74	91	130	80	82	107	128	129	139	111	97	142	143	62
Age of animal	2 years	3 years	5 years	7 years	5 weeks	1 year	Old	2 years	6 years	1½ years	1 year	1½ years	1½ years	2 years.
No. of field	1 and II	I	I	II	II	II	II	II	II	I	I	I	I	II.
Date of exposure	May 26 and Sep. 25	May 26	July 9	July 5	July 5	July 5	July 4	July 5	Aug. 30	Sept. 1	Aug. 25	Sept. 16	Sept. 16	Sept. 25.
Result of exposure	Died	Negative.	Negative.	Died	Died	Recovered.	Died	Died	Died	Died	Negative.	Slightly affected.	Negative.	Negative.
Died, days after exposure	21			54	154		59	55	14	107				
Sept. 3, 10 a. m	100.8	100.6	101		101.7	102.2	Dead.		101	100.8	100.8			
Sept. 5, noon	101.4	101.5	102		103.2	102.5			101.4	102.4	101.8			
Sept. 8, 10 a. m	100.2	100.9	100.6		102.5	102.3			101.8	105.4	100.2			
Sept. 10, 10 a. m	101.1	101	101.2		102.2	102.9			106	102.6				
Sept. 12, 8:30 a. m	101.7	101.6	101.8		103.2	101.7			106.1	103				
Sept. 15, 10 a. m	100	100.3	100.8						Dead.	102				
Sept. 17, 1 p. m	101.4	102	102.8							102.4	102.6	101.8	103.2	
Sept. 19, 10 a. m	100.4	100.2	101.2							100.8	100.6	100.8	101	
Sept. 20, 10 a. m	100.4	108.8	101							101.4	100.5	101.4	101.8	
Sept. 22, 10 a. m	101.2	100.6	101.2							100.2	101.5	100.8	101.2	
Sept. 23, 10 a. m	100.5	100.8	101.5							100.4	101.4	100.8	100.5	
Sept. 25, 10 a. m	101.4	100.6	101.2							98.4	100.8	100.8	101.2	102.4
Sept. 27, 2 p. m		101.5	102.2							101.5	100.8	100.8	101.2	
Sept. 30, 10 a. m	101.4	101*	101.6		103	102.4				101.2	100.4	103.4	101.2	100
Oct. 4, 9:30 a. m	100.5		101		102.6	102.8				101.2	101	100.2	100.6	101
Oct. 6, 9:30 a. m	101.2		102.6		102.7	102				102	101.5	100.8	101.8	101.7
Oct. 9, 9:30 a. m	100.8		103		102.5	103				101.8	101.5	101.4	102	101.2
Oct. 11, 10 a. m	106.5		102		102.5	102.8				100.5	101.2	100.2	101	102
Oct. 14, 10 a. m	106.7		101.8		101	102				100	100.8	101.6	101	100.8
Oct. 20, noon	Dead		103		102.1	101.6				101.2	100.3	102.2	101.7	101.4

* October 1 transferred to field VI.

Field II, 1890.

No. of animal.	80.		82.		107.		128.		129.		139.	
Temperature taken.	Morn.	Eve.	Morn.	Eve.	Morn.	Eve.	Morn.	Eve.	Morn.	Eve.	Morn.	Eve.
July 24	102.2	101.4	101.5	102.2	101.8	102	102.2	104.7	100.8	101.4	......	......
July 25	100.8	102.9	101.9	102.5	100.4	103	100	103.9	100.7	101.8	......	......
July 26	100.7	102.8	103	102.8	101	102	101.4	103.2	100.8	101.6	......	......
July 27	102	103.6	101.5	102.8	101.9	103.1	101.4	102	101.2	101.8	......	......
July 28	102.2	101.8	101.6	102.5	101	101.8	100.2	101.5	100.8	102	......	......
July 29	101.4	104.2	101.4	102.6	101.3	102.3	100.2	103.2	101	102.4	......	......
July 30	103	103.8	101.6	102.5	102	103.7	100.6	103.2	101.3	101.8	......	......
July 31	101.5	103.6	101.7	102.4	101.6	102.6	101.1	103.8	101.4	101.8	......	......
Aug. 1	105.1	102.8	102.1	102.2	102.4	102.6	103	102.5	101.8	102	......	......
Aug. 2	102.5	104.2	102.2	102.8	101.1	103	101.8	104	101.2	102	......	......
Aug. 3	102.5	103.6	102	102.7	102.8	102.8	103.2	103.6	101.2	101.6	......	......
Aug. 4	101.4	103.6	101.2	102.2	101.2	102.5	101.8	104	101	102	......	......
Aug. 5	101.2	103.8	101.2	102	100.5	102.7	102.5	104	100.8	101.6	......	......
Aug. 6	100.8	103.2	101.5	101.8	101	103	102.8	104	101.2	101.5	......	......
Aug. 7	101	101.8	101.4	101.8	101.3	102.2	102.4	104	101	101.6	......	......
Aug. 8	100.6	101.6	101.6	102.8	100.7	101	100.8	102.8	101	102.2	......	......
Aug. 9	100.8	102.5	101.4	102.4	101.5	103.2	101.8	104.1	104.1	102.3	......	......
Aug. 10	101.2	101.4	101.9	102.6	102.6	103	103	102.8	101.5	101.8	......	......
Aug. 11	100.1	101.2	101.2	102.3	101.4	102	100.2	103.2	100.8	102.2	......	......
Aug. 12	100.8	101.6	102	102.8	101.6	102.7	101.5	102 6	101.2	103.2	......	......
Aug. 13	100.7	101.6	100.7	102.6	100.8	103.6	100.6	103	100.5	101.8	......	......
Aug. 14	100.2	102.5	101	103	101	103.8	100.6	103.6	100.3	101.8	......	......
Aug. 15	101.2	101.8	101.7	102 7	102	103.5	101.8	103.4	102	101.6	......	......
Aug. 16	100.2	102.3	101.6	102.2	100.8	103.2	100.7	103.2	100.6	101.8	......	......
Aug. 17	101.2	102.4	101.5	102.9	101.8	103.2	101.4	103	100.8	101.5	......	......
Aug. 18	101	101.4	102	102	102.1	101.2	101.2	101.3	101.2	101.5	......	......
Aug. 19	101.4	101.6	102.2	102.7	101.6	103.8	102.2	102.4	101.3	101.6	......	......
Aug. 20	100.8	102	102.1	103	101.5	104	101.2	102.8	101.4	101.6	......	......
Aug. 21	100.8	104.8	101.8	103	101.4	104.6	100.7	102.2	100.4	102	......	......
Aug. 22	102.6	104.8	101.7	103.6	102.5	105	100.7	102.2	100.6	102	......	......
Aug. 23	101.6	104.8	102	104	104.8	105.4	100.1	102.5	100.5	102	......	......
Aug. 24	104.7	105.7	102.2	103.2	105.8	105.5	100.2	101.5	104	104.8	......	......
Aug. 25	106.2	106.8	102.3	104.5	104.5	105.6	100.2	102.2	106	106.4	......	......
Aug. 26	105.8	106.6	102.8	103.8	104.5	103.8	100.7	102.6	106.4	106.3	......	......
Aug. 27	106	104.8	103.1	103.8	104.2	105.4	101.5	105.6	106.6	106.2	......	......
Aug. 28	102.7	Dead.	102.5	104.4	103.4	105	103	104.5	105.6	104.6	......	......
Aug. 29	......	......	103	104	104.6	105	104.7	107.1	101.2	100.1	......	......
Aug. 30	......	......	102	103	103.4	104.7	105.	107	Dead.	......	......	101.8
Aug. 31	......	......	101.2	......	104.7	......	106.	......	......	......	100.5	......
Sept. 1	......	......	102.3	103	102.2	101.3	98	Dead.	......	......	100.8	101.2
Sept. 2	......	......	100.8	102.4	101.2	101.4	......	......	......	......	100.6	101.3
Sept. 3	......	......	101.7	102.9	102.2	103.8	......	......	......	......	101	102
Sept. 4	......	......	102	102.5	101.4	102.8	......	......	......	......	101	101.6
Sept. 5	......	......	103.2	103.4	102.5	103.4	......	......	......	......	101.4	101.7
Sept. 6	......	......	102.5	102.6	102	104.4	......	......	......	......	101.2	102
Sept. 7	......	......	102	103.9	102.5	103.8	......	......	......	......	101.4	102.6
Sept. 8	......	......	102.5	103.2	102.3	103.8	......	......	......	......	101.8	103.4
Sept. 10	......	......	102.2	103.7	102.9	103.4	......	......	......	......	106	105.2
Sept. 11	......	......	101.4	101.2	101.2	101.8	......	......	......	......	105.2	106
Sept. 12	......	......	103.2	103	101.7	102.6	......	......	......	......	106.1	102.4
Sept. 13	......	......	......	......	......	......	......	......	......	......	Dead.	......

Field VI, 1890.

No. of animal	32	49	50	51	53	57	59	61	64	66	67	69	75
Age of animal	3 years	4 years	4 years	4 years	2½ years	10 years	5 years	2 years	3 years	2 years	5 years	3 years	16 mos.
Date of exposure	July 4	July 4	July 4	July 4	July 4	July 4	July 4	July 4	July 4	July 4	July 4	July 4	July 4.
Result of exposure	Negative	Recovered.	Died	Died	Negative	Negative	Negative	Negative	Recovered.	Died	Negative	Died	Negative.
Died, days after exposure	....	....	64	53	....	....	....	....	....	59	....	61	....
July 5, noon	102.7	102	102.4	102	101.4	101.9	102.2	102	101.5	102.3	102.1	101.9	102
July 7, 4 p.m.	103	103.8	103.2	104.6	102.6	101.7	103.2	102.5	101.8	102.5	104.2	103.6	106
July 8, 6 p.m.	102.5	103.3	103.7	104	102.8	102.1	102.9	103.2	102.8	102.4	103.8	102.8	105
July 9, 9 a.m.	102	101.8	101.4	100.8	101	101.6	102.2	102.5	101.9	101.8	102.2	102.1	102
July 9, 6 p.m.	102.4	102.9	102.4	103.2	101.6	102	103	103.2	102	102.8	102.7	102.5	104.4
July 11, 9 a.m.	101	101.8	101.4	100.4	101.2	101.2	101.6	101.4	100.6	101.6	101.2	101.3	101.6
July 12, 10 a.m.	101.7	101.4	101.5	101	101.4	101.4	101.8	102.2	102.4	101.6	101.2	101.6	101
July 14, 10 a.m.	101.1	101.4	100.8	100.4	101	100.8	101.5	101.3	101.5	101.2	101.3	100.3	100.8
July 16, 9 a.m.	101.6	101.5	101.8	100.8	101.3	101	102.2	101.4	101.5	101.5	102.3	102.2	102.4
July 16, 6 p.m.	102.8	102.2	102.3	103	101.6	101.3	102.4	102.8	101.8	102.5	103	102.4	103
July 18, 9 a.m.	100.8	101.2	101.2	100.2	100.8	101	101.7	101.6	101.4	101.6	101.4	100.8	101.2
July 19, 9 a.m.	100.8	101.2	101.5	100.8	100.8	100.4	100.8	101.1	100.8	101.6	101.5	100.6	100.5
July 21, 10 a.m.	100.8	*101	100.7	101	101	101	100.8	101.4	101.4	101.2	101.1	100.8	101
July 22, 9 a.m.	101	100.6	101	100.8	100	100.4	101	101.4	101	101.4	100.2	100.7	99.8
July 23, 9 a.m.	101.5	101	100.8	100.8	100.8	101.2	101.1	101.8	101	101.2	100.8	100.8	101.2
July 25, noon	101.1	100.7	100.5	100.7	100.6	100.7	101	101.4	101.2	101.3	101.5	100.8	101.5
July 26, 11 a.m.	102	102.2	101	100.7	101.8	101.4	101.6	101.7	101.8	101.8	101.5	101.4	101.8
July 28, 11 a.m.	101.5	101.4	100.6	100.8	101.2	100.7	101.6	101.2	101.3	101.6	100.2	101	101
July 30, 10 a.m.	101.2	101.6	101.1	100.5	101.1	101.1	101	101.4	101.2	101.2	100.8	100.7	100.7
Aug. 1, 9 a.m.	101.6	101.1	101.4	101	101	101	101.3	101.1	101	101.2	100.7	101.5	101.2
Aug. 2, 10 a.m.	101	100.4	100.7	101.1	101.7	100.9	101.2	100.5	101	103.4	100.6	100.4	100.6
Aug. 4, 9 a.m.	100.8	101	100.8	100.2	101	101	101.1	100.8	101.2	101	100.3	100.4	100.5
Aug. 6, 10 a.m.	102	100.8	100.4	101	101	100.8	101.4	101.2	101.2	102	101	100.7	101
Aug. 8, 10 a.m.	100.6	101.1	101.2	100.1	100.8	101.2	101.5	101.4	101	101.4	100.3	101.2	101.3
Aug. 9, 10 a.m.	101.7	101	101	101.4	100.4	100.7	101.2	101	101.1	101.2	100.5	100.8	100.3
Aug. 11, 10 a.m.	100.5	100.8	100	100.1	100.1	100.7	101.4	101	100.7	101.2	100	100.6	100.5
Aug. 13, 10 a.m.	101.4	100.6	101	100	100.5	100.4	100.5	100.8	100.9	101.8	101	100.7	100.2
Aug. 15, 10 a.m.	101.8	100.8	100.8	100.3	101	100.5	101.4	101.5	100.8	101.6	101	100.9	101.2
Aug. 16, 10 a.m.	101.7	101.2	102.2	100.9	100.3	100.5	100.8	101	101.1	101.6	100.8	100.7	100.2
Aug. 18, 2 p.m.	101.7	103.2	101.9	105.9	102	101.2	101.6	102	105.9	103	102.4	102.6	102.2
Aug. 19, 10 a.m.	102	104	101.6	103.8	101.5	101.4	101.4	101.5	105.8	102.2	101.8	101.6	101.4
Aug. 21, 10 a.m.	101.5	*106.7	101.4	107	100.8	101.2	100.8	101.1	106.7	103	101	101.9	101
Aug. 23, 10 a.m.	100.5	105.7	101.6	105.8	102.3	100.5	101	101.4	104.2	102.5	100	105.8	100.3
Aug. 25, 10 a.m.	101.6	101	102.2	104	99.8	101.8	101	101	103.5	101.8	100.6	106.7	101.2
Aug. 27, 10 a.m.	103.4	101.5	104	Dead ...	100.9	101.3	101.2	101	100.9	102.2	100.9	104.2	101.4
Aug. 29, 10 a.m.	102	101.5	103	....	100.7	101.4	100.8	101	100.4	104	100.7	103.2	101.2

*Transferred to field IV.

Field VI, 1890—Continued.

No. of animal	32	49	50	51	53	57	59	61	64	66	67	69	75
Age of animal	3 years	4 years	4 years	4 years	2½ years	10 years	5 years	2 years	3 years	2 years	5 years	3 years	16 mos.
Date of exposure	July 4	July 4	July 4	July 4	July 1	July 4	July 4	July 4	July 4	July 4	July 4	July 4	July 4.
Result of exposure	Negative	Recovered.	Died	Died	Negative	Negative	Negative	Negative	Recovered.	Died	Negative	Died	Negative.
Died, days after exposure			64	53						59		61	
Aug. 30, 10 a. m	102.2	102	106.1		100.7	100	100.6	100.3	100.5	105.5	100.8	101.4	101
Sept. 1, 10 a. m	100.3	100.3	105.8		101.1	100	100.6	100.3	101.6	Dead	100	103.5	100
Sept. 3, 10 a. m	101	100.6	*100		100.6	100	100.7	101.2	103.5		100.8	Dead	100.9
Sept. 5, noon	103	102	101		102.2	101.4	101.8	102	102.9		102.2		103.3
Sept. 8, 10 a. m	101	101.8	Dead		100	100.4	100.6	100.7	101.4		100.8		100
Sept. 10, 10 a. m	100.8	102			100.6	101.2	101.2	101.4	101		102		100.7
Sept. 12, 5 p. m	101.3	102			102.4	102.7	101.6	101.4	101.1		101.8		102.1
Sept. 15, 10 a. m	100.2	99.6			100.7	102	99.6	101.1	100.1		99.4		100.8
Sept. 17, 1 p. m	102.4	102			102.1	102	102.2	101.6	102.4		103		102.5
Sept. 19, 10 a. m	101.2	101			100.2	100.3	100.6	101	100.7		100.8		101
Sept. 20, 10 a. m	101.7	101.2			100.5	100.6	100.7	101.2	101.3		101.3		100.8
Sept. 23, 10 a. m	101.3	100.8			100.3	100.4	101.4	101.9	101.5		100.6		100.5
Sept. 25, 10 a. m	101.2	101.5			100.7	101	100.7	101	102.1		101.5		100.2
Sept. 27, 2 p. m	102.4	103.6			103	103	101.8	101.9	102.2		102.1		101.7
Sept. 30, 10 a. m	101.7	100.6			100.6	101.7	101	101.6	101.4		101.5		100.5
Oct. 4, 9:30 a. m	101	100.6			100.6	100.5	100.5	100.8	100.8		100.3		100.6
Oct. 6, 5 p. m	102.4	101			103	102.6	102.5	102.7	102		102.8		102.4
Oct. 9, 9:30 a. m	101.8	102.8			101	101	101.8	101.4	101.3		101.4		101.2
Oct. 11, 10 a. m	101.2	101.4			100.6	101	101.8	101	101		101.5		100.5
Oct. 14, 10 a. m	101.8	101.6			101	101.2	101.6	101.5	102		101		101.5
Oct. 20, noon	101.5	101			101.5	102.2	101	100.8	101		100		100.8

* Transferred to field IV.

Field VI, 1890—Continued.

No. of animal	79	85	86	87	93	95	100	71	134	90	56	65	89	91
Age of animal	3 months	3 months	2 months	3½ months	1½ months	4 years	2 months	4½ years	2 years	1 year	3½ years	3 years	6 months	3 years
Date of exposure	July 4	July 4	July 4	July 4	July 4	July 4	July 4	Aug. 13	Aug. 13	Aug. 25	Sept. 8	Sept. 20	Sept. 20	Oct. 1
Result of exposure	Recovered.	Recovered.	Recovered.	Recovered.	Died	Died	Died	Died	Died	Died	Recovered.	Died	Died	Negative.
Died, days after exposure					80	52	162	24	15	22		43	100	
July 5, noon	102.9	102.6	103	103.2	104	103.5	103							
July 7, 4 p. m	104.2	103.4	104.2	103.6	105.3	105.4	103.3							
July 8, 6 p. m	103.8	103	104.8	104	104.8	104.3	103.5							
July 9, 9 a. m	102.6	102.5	103.4	102.2	103.2	102.9	102.4							
July 9, 6 p. m	103	102.8	103.8	103.4	103.8	102.9	102.8							
July 11, 9 a. m	102.4	101.8	101.9	102.1	102.2	101.8	100							
July 12, 10 a. m	102.2	102	102.7	102.8	102.3	101.3	101.6							
July 14, 10 a. m	101.4	101.7	102	102.2	101.9	101	101.5							
July 16, 9 a. m	102.5	101.7	102.6	102.4	102.6	102.2	101.8							
July 16, 6 p. m	103.2	102.8	103.4	103	104.2	103	102.6							
July 18, 9 a. m	102.6	101.6	103	102.2	102.2	101.2	101.2							
July 19, 9 a. m	102	101.6	102.6	102.4	102.6	100.6	100.8							
July 21, 10 a. m	102	101.8	102.2	102.2	102	101	101.6							
July 22, 9 a. m	102.2	101.8	102.4	102.2	102.2	100.8	101.2							
July 23, 9 a. m	102.5	102.2	102	102.3	102	101	101.6							
July 25, noon	102.5	101.8	102.4	102.3	102.2	100.6	101.5							
July 26, 11 a. m	102.7	101.2	102.2	102.2	102.4	101.2	102.5							
July 28, 11 a. m	103	101.5	102	102.5	102.2	100.8	101.6							
July 30, 10 a. m	102.9	101.4	101.8	101.8	102.8	100.7	102.1							
Aug. 1, 9 a. m	102.8	101.6	103.2	101.9	101.7	101.5	101.3							
Aug. 2, 10 a. m	102.6	101.4	102.2	102.3	102.5	101	101.9							
Aug. 4, 9 a. m	102.4	101.4	103	101.8	102.6	100.8	101.8							
Aug. 6, 10 a. m	103	101.4	102.5	102.2	101.8	102.2	101.7							
Aug. 8, 10 a. m	102.4	101.6	101.4	100	102	101.8	101.6							
Aug. 9, 10 a. m	102.2	101.6	101.9	101.8	101.9	102.8	101.7							
Aug. 11, 10 a. m	102.2	100.8	101.9	102	102.1	102.7	100.8							
Aug. 13, 10 a. m	102.6	100.0	102.4	101.5	102.6	102.2	101.4							
Aug. 15, 10 a. m	102.8	102.4	102.1	102.2	104.5	101.7	102.6	101.5	102.4					
Aug. 16, 10 a. m	102.3	102.5	101.8	101.2	104.4	101	102.4	100.6	100.5					
Aug. 18, 2 p. m	102.8	103	103.2	105	103.8	102	101.8	101.6	102.2					
Aug. 19, 10 a. m	103.4	101.4	103	104.5	103.8	105.2	101.5	101.7	102					
Aug. 21, 10 a. m	102.6	*101.2	105.5	107	105.	105.6	101.3	101	100.7					
Aug. 23, 10 a. m	103.6	103.4	105.7	105.2	102.6	102.7	101.6	100.3	102					
Aug. 25, 10 a. m	106.5	103.7	106	104.5	104.6	100.5	103.6	102.5	106.6					
Aug. 27, 10 a. m	105.2	105.8	104.3	102.4	105.5	Dead	104	106.2	106.4	101.2				
Aug. 29, 10 a. m	102.4	105.5	102.5	101.5	104		103.8	106.5	97.4	101				

* Transferred to field IV.

Field VI, 1890—Continued.

No. of animal	79	85	86	87	93	95	100	71	134	90	56	65	89	91
Age of animal	3 months	3 months	2 months	3½ months	1½ months	4 years	2 months	4½ years	2 years	1 year	3½ years	3 years	6 months	3 years.
Date of exposure	July 4	July 4	July 4	July 4	July 4	July 4	July 4	Aug. 13	Aug. 13	Aug. 25	Sept. 8	Sept. 20	Sept. 20	Oct. 1.
Result of exposure	Recovered.	Recovered.	Recovered.	Recovered.	Died	Died	Died	Died	Died	Died	Recovered.	Died	Died	Negative.
Died, days after exposure	...	...	...	...	80	52	162	24	15	22	...	43	100	...
Aug. 30, 10 a. m	102.1	104.2	101.8	102	104.1	...	103.7	106.6	Dead	100.8	...	...	...	...
Sept. 1, 10 a. m	103.2	103.5	102.4	101.7	105	...	101.6	105.5	...	100.8	...	...	...	...
Sept. 3, 10 a. m	101.8	102.8	101.9	102	101	...	104.6	104.2	...	101	...	...	...	...
Sept. 5, noon	104.6	103	103.5	102	105.2	...	104.8	103.4	...	104	...	...	...	...
Sept. 8, 10 a. m	101.2	102.1	101.8	101.4	101	...	101.4	Dead	...	105.2	...	...	...	...
Sept. 10, 10 a. m	102.7	102.8	103.4	102.2	102	...	102.3	...	...	105.8	101.4	...	...	...
Sept. 12, 5 p. m	104	102.8	102.6	102.6	103.6	...	103.5	...	...	103.4	101	...	...	...
Sept. 15, 10 a. m	100.6	99	101.5	100.2	100	...	99.4	...	...	101.6	100.2	...	...	...
Sept. 17, 1 p. m	104	103.4	103.8	103	104.2	...	103.8	...	...	Dead	101.4	...	...	...
Sept. 19, 10 a. m	102.5	102	102.2	102.6	102.6	...	101.4	...	...	...	101.2	...	...	...
Sept. 20, 10 a. m	103	102.4	102.2	102.1	103.2	...	101.9	...	...	...	100.8	102.4	102.2	...
Sept. 23, 10 a. m	103.4	101.8	102.6	102.2	Dead	...	102.4	...	...	...	102.8	100.7	102	...
Sept. 25, 10 a. m	101.6	101.7	102	102.5	...	...	101.2	...	...	...	103.2	100.7	102	...
Sept. 27, 2 p. m	103.8	102.8	103	104	...	...	103.6	...	...	...	102.7	102.2	102.6	...
Sept. 30, 10 a. m	103.2	103.2	102.6	103.4	...	...	103.6	...	...	...	101.6	100.8	104.0	...
Oct. 4, 9:30 a. m	102.2	102.8	102	102.6	...	...	101.8	...	...	...	101.8	100.4	103.8	100.5
Oct. 6, 5 p. m	106	102.4	105	103.2	...	...	103.2	...	...	...	102.5	102.6	104.5	103.5
Oct. 9, 9:30 a. m	103.4	103.6	103.2	102.8	...	...	103.8	...	...	...	101.6	101.4	104.5	101.8
Oct. 11, 10 a. m	102.7	102.3	103.2	102.3	...	...	102.6	...	...	...	101.2	101	103.8	101
Oct. 14, 10 a. m	103	102.3	102.8	103	...	...	102.7	...	...	...	100,8	101.2	101.8	101.8
Oct. 20, noon	102.5	100.9	102.9	103	...	...	102.5	...	...	...	101.7	101.4	102.3	101.5

Fields VII, VIII, and IX, 1890.

No. of animal	103	106	108	76	102	105	73	101	104	47	135
Age of animal	3 years	2 years	2 years	1 year	6 years	2 years	6 years	1 year	3 years	4½ years	2 years.
Number of field	VII	VII	VII	VIII	VIII	VIII and IV.	IX	IX	IX	VIII and IV.	VIII and IV.
Date of exposure	July 4	July 4	July 4	July 4	July 4	July 4	July 4	July 4	July 4	Aug. 21	Aug. 21.
Result of exposure	Died	Died	Died	Died	Recovered	Recovered	Negative	Negative	Negative	Died	Recovered.
Died days after exposure	64	55	67	45	....	....	....	....	....	22	....
July 5, noon	102.3	101.2	101.4	102.8	102.8	102	101.4	101.8	101.8	....	....
July 7, 4 p.m	102.2	101.9	101.7	101.9	102.8	101.8	102	103.5	102.3	....	....
July 8, 6 p.m	102.5	102.6	103	102.2	102.4	101.8	102.3	103	102.7	....	....
July 9, 9 a.m	102	101.8	102	103.2	103	101.6	102	102	102	....	....
July 11, 9 a.m	102.5	101.5	101.4	101	102.8	101.4	101.2	102.5	101.4	....	....
July 12, 10 a.m	102.2	101.6	101.5	102.2	102.3	101.4	101	102.2	101.2	....	....
July 14, 10 a.m	101.6	101.4	100.8	101	101.5	101.6	101.8	102	101	....	....
July 16, 9 a.m	101.8	101.9	102	102.2	102.8	101.8	102.8	102.2	101.6	....	....
July 18, 9 a.m	101.5	101.6	101.4	101.5	100.8	101.4	101	101.4	101.4	....	....
July 19, 9 a.m	101.5	100.8	101.4	102.5	102.4	101.8	101.1	101.5	101	....	....
July 21, 10 a.m	102	101.6	101.4	101.4	101.8	101.2	101.4	101.3	101	....	....
July 22, 9 a.m	101.5	101.4	101.6	101.4	102	101.5	101.1	101.3	101	....	....
July 23, 9 a.m	101.6	101.9	101.3	101	101.9	101.4	100.8	101	101.2	....	....
July 26, 11 a.m	102	101.5	102.5	102.3	102.7	101.6	100.8	100.7	101.3	....	....
July 28, 11 a.m	101.8	101.5	101.4	101.5	101.9	104.2	101	100.6	101.4	....	....
July 30, 10 a.m	101.8	102	101.2	102	102.4	102.8	101.1	101.2	101.7	....	....
Aug. 1, 9 a.m	102.4	101.8	102	103.6	102.8	103.8	101.7	102.6	102	....	....
Aug. 2, 10 a.m	101.3	102.2	101.4	100.8	102.2	104.4	101	101.6	101.4	....	....
Aug. 4, 9 a.m	101.6	102.4	101.4	100.8	102	101.4	101	101.4	101.4	....	....
Aug. 6, 10 a.m	102.3	102	101.7	102.2	103.5	101.8	101.4	102	301.6	....	....
Aug. 8, 10 a.m	102	101.6	101.5	101.7	102.8	101.8	101.2	101.5	102	....	....
Aug. 9, 10 a.m	102	101.5	101.6	101.5	102.8	101.6	101.2	101.1	101.1	....	....
Aug. 11, 10 a.m	102.2	101.5	101	101.9	102.9	101	103	101.5	101.6	....	....
Aug. 13, 10 a.m	103.8	101.7	101.8	104.2	102.9	105.8	101.9	102.1	101.6	....	....
Aug. 15, 10 a.m	104	101.8	101.6	106.2	102	106.7	101.1	101.8	102.4	....	....
Aug. 16, 10 a.m	102.8	101.2	101.1	107	101.9	106.9	101.7	102.8	102	....	....
Aug. 18, 2 p.m	102.5	101.4	100.8	99.7	101.7	106	101.2	102.8	101.6	....	....
Aug. 19, 10 a.m	103.3	101.2	100.9	Dead	101.9	105.3	100.8	101.6	101.2	....	....
Aug. 21, 10 a.m	103.8	102	101.4	....	103	*104.8	101.6	102.3	102	102.8	103.5
Aug. 23, 10 a.m	102.6	102.5	100.9	....	102.8	103.6	100.7	101	100.9	101.5	101
Aug. 25, 10 a.m	103	105.9	101.7	....	105.5	100.7	101	102.2	102	101.8	103
Aug. 27, 10 a.m	102.4	105.8	105.6	....	102.7	101.3	101.9	102.2	101.5	101.2	101.2
Aug. 29, 10 a.m	102.3	Dead	105.8	....	103	103.6	100.8	101.8	101.2	100.5	100.8
Aug. 30, 10 a.m	104	....	106.9	....	101.6	102.2	101.5	101.8	101.6	101.3	103.2
Sept. 1, 10 a.m	106.7	....	106.4	....	101.6	100.8	101	102.3	102	103.6	103.4

* Transferred to field IV.

Fields VII, VIII, and IX, 1890—Continued.

No. of animal	103	106	108	76	102	105	73	101	104	47	135
Age of animal	3 years	2 years	2 years	1 year	6 years	2 years	6 years	1 year	3 years	4½ years	2 years.
Number of field	VII	VII	VII	VIII	VIII	VIII and IV.	IX	IX	IX	VIII and IV.	VIII and IV.
Date of exposure	July 4	July 4	July 4	July 4	July 4	July 4	July 4	July 4	July 4	Aug. 21	Aug. 21.
Result of exposure	Died	Died	Died	Died	Recovered	Recovered	Negative	Negative	Negative	Died	Recovered.
Died days after exposure	64	55	67	45						22	
Sept. 3, 10 a. m	106.7		106.2		102.6	100.1	101.7	102.7	102.6	105.8	104.5
Sept. 5, noon	105.8		104.3		101	102.2	100.7	102.2	100.8	*106	104.2
Sept. 8, 10 a. m	Dead		102.2		103.8	102.2	101.5	101.4	101.8	105.9	*106
Sept. 10, 10 a. m			Dead		105	102.2	100.8	101.6	102.6	105	102.3
Sept. 12, 8:30 a. m					102.6	102.2	102	102.5	103	Dead	102.4
Sept. 15, 10 a. m					101.2	99.8	100.5	101.2	101		100.5
Sept. 17, 1 p. m					102.1	102.8	102.4	101.9	102		104.6
Sept. 19, 10 a. m					102.1	101.4	101.3	102	101.4		102.3
Sept. 20, 10 a. m					103	101.7	101.4	102.5	101.8		102.8
Sept. 23, 10 a. m					101.2	101	101.7	102.3	102.1		100.7
Sept. 25, 10 a. m					102	100.8	101	102	101.2		101
Sept. 27, 2 p. m					101.6	102.6	101.4	102.1	101.8		103.8
Sept. 30, 10 a. m					103.6	101	101.6	103.2	103		101.2
Oct. 4, 9:30 a. m					102.5	100.5	101.6	103	101.5		101.5
Oct. 6, 9:30 p. m					101.5	101	102	102	101.8		101.5
Oct. 9, 9:30 a. m					100.8	103.2	101.2	101	100.8		102
Oct. 11, 10 a. m					102.2	101	101.8	102.6	102		101
Oct. 14, 10 a. m					103.4	102.5	102.2	102.8	102.5		102
Oct. 20, noon					101	103.2	101	101.6	101.8		101.6

Transferred to field IV.

Miscellaneous experiments, 1890.

No. of animal	131	110	138	132	133	109	136	137	140	144	145
Age of animal	2 years	1 year	1 year	2½ years	2½ years	10 years	5 years	1 year	2 years	8 or 10 years	1½ years.
Place of exposure	Stable	Stable	Stable	Field IV	Field IV	Field V	Field V	Field X	Stable	Field X	Stable.
Date of exposure	July 29	Aug. 14	Aug. 14	Aug. 21	Aug. 21	Aug. 25	Aug. 25	Sept. 9	Sept. 9	Sept. 17	Sept. 17.
Result of exposure	Negative	Negative	Recovered	Slightly affected.	Slightly affected.	Negative	Negative	Died	Died	Died	Negative.
July 30, 10 a. m	101.2										
Aug. 1, 9 a. m	101.8										
Aug. 2, 10 a. m	101.8										
Aug. 4, 9 a. m	101.7										
Aug. 6, 10 a. m	101.6										
Aug. 8, 10 a. m	102.2										
Aug. 9, 10 a. m	101.2										
Aug. 11, 10 a.	100.6										
Aug. 13, 10 a. m	101.4	101.3	101.9								
Aug. 15, 10 a. m	101	101.6	101.8								
Aug. 16, 10 a. m	101.5	102.1	101.9								
Aug. 18, 2 p. m	101.2	102.1	101.5								
Aug. 19, 10 a. m	101.2	102	101.6								
Aug. 21, 10 a. m	101.3	102	101.2	103	103						
Aug. 23, 10 a. m	100.8	101.8	100.9	101.9	101.8						
Aug. 25, 10 a. m	100.5	101.6	100.7	100.6	100.5						
Aug. 27, 10 a. m	101.4	102.2	101.6	101.3	101.2	101.6	101.7				
Aug. 29, 10 a. m	100.8	102	100.8	101.4	101.6	101.6	101.6				
Aug. 30, 10 a. m	101	102	105.8	103	103	101	101.3				
Sept. 1, 10 a. m	100.4	101.6	102.5	100.5	100.4	100.4	100.2				
Sept. 3, 10 a. m	100.8	101.7	103.8	100.8	100.7	100.3	100.6				
Sept. 5, noon	101.2	102.8	102.6	101.4	101	101	100.7				
Sept. 8, 10 a. m	101.1	101.6	101.2	101.1	100.6	100.6	100.5				
Sept. 10, 10 a. m	101.7	102	102.6	101.6	101.5	101.2	101				
Sept. 12, 8:30 a. m	101.4	101.1	103.1	101.8	101	101.2	101.8				
Sept. 15, 10 a. m	101	102.6	101.8	99.5	99	100.2	98.2				
Sept. 17, 1 p. m	101.8	101.8	101.7	101.6	101.4	101.8	101.2			103	102.5
Sept. 19, 10 a. m	100.5	102.8	102.6	101.2	101.5	100.6	100.4				101.2
Sept. 20, 10 a. m	100.8	103.6	101.4	101.8	101.2	102.2	101.5				
Sept. 22								106.5	105.5		
Sept. 23, 10 a. m	101	102.6	105.9	100.9	101.2	100.8	100.4				
Sept. 25, 10 a. m	101	102.2	106	101	101.2	100.7	100	103.5	105.2	100.6	100.4
Sept. 27, 2 p. m	101.2	102	105.5	104	103.2	101.5	101.8	103.8	105	104	101.4
Sept. 29, 10 a. m	101.7	101.6	103					103.4		106.2	
Sept. 30, 10 a. m	101.5	101.4	102	101.6	101.4	100.7	100.2	104.8	102.5	107	101.2
Oct. 4, 9 a. m	100.8	102.6	101.6	100	101.6	100.4	100		Dead	Dead	
Oct. 6, 9 a. m	101.6	102.6	102.8	101.8	102.2	100.6	100.4	102.5			101.4
Oct. 9, 10 a. m	101.8	102.2	103.6	102.2	102.5	100.8	101.2	102			101.4
Oct. 11, 10 a. m	101.8	102	102.2	101.8	101.7	100.8	100.6	103			101.2
Oct. 14, 10 a. m	101.2	102.2	101	100.8	101.5	100.5	99	102.2			100.8
Oct. 20, noon	101.4	101.8	101.1	102.2	101.8	101.3	100	102.2			101.4

Animals in stable artificially heated, 1890.

Date.	Temperature of stable.		62.		143.		145.		149.		117.	
	Morning.	Evening.	Morning.	Evening.	Morning.	Evening.	Morning.	Evening.	Morning.	Evening.	Morning.	Evening.
Oct. 30	70	....	102.5	....	101.9	....	101.9	....	102.3	....	....	....
Nov. 1	74	....	101.8	....	102.3	....	101.4	....	101.8	....	....	....
Nov. 2	70	78	101.7	102.2	102.8	103.3	101	101.9	102	100.2	....	....
Nov. 3	68	67	101.6	102	102.4	102.8	101.8	101.7	102.6	102.2	....	....
Nov. 4	70	....	101.6	....	102	....	102	....	101.6	....	....	....
Nov. 5	67	....	101.7	....	103.1	....	101.4	....	102.3	....	....	....
Nov. 6	65	80	101.6	101.4	103	103.2	101.3	101.8	102.5	102.7	....	....
Nov. 7	67	....	102	....	103.1	....	101.3	....	101.5	....	....	....
Nov. 8	70	84	101.9	101.4	102.8	103.8	101.4	101.4	102	103	....	....
Nov. 9	72	80	101.2	102.2	103.8	105.8	101.2	101.5	101.8	103.5	....	....
Nov. 10	76	....	101.5	....	104.3	....	101.2	....	102.2	....	....	....
Nov. 11	75	....	101.6	....	103.2	....	101.2	....	102.4	....	....	....
Nov. 12	72	74	101.7	101.9	103.3	103.5	101.3	101.4	104.5	104.1	....	....
Nov. 13	73	80	102.2	101.7	103.3	104.3	101.5	101.8	103.8	104.7	....	....
Nov. 14	72	80	101.5	102.4	103.3	103.8	101.3	102.7	103	103.4	....	....
Nov. 15	80	83	102.4	102.1	103.2	104.4	102	102	103.4	103.7	....	....
Nov. 16	74	72	101.5	102	103.2	103.2	100.9	102.1	102.3	102.7	....	....
Nov. 17	72	76	102.2	102.2	103.6	103.9	101.7	102	102.1	103.5	....	....
Nov. 18	72	81	102	101.8	103.8	103.4	101.5	101.4	102.4	102.8	....	....
Nov. 19	78	70	102	102.4	103.2	103.5	101.2	101.5	102.8	163	....	102.4
Nov. 20	70	78	102	101.8	102.7	103.2	101	101.2	102.1	102.1	102.1	103
Nov. 21	74	80	101.6	102	105	104.2	101.4	101.8	103.1	102.6	102	103
Nov. 22	79	78	102	101.8	104	104	102.5	102	103.6	103.2	102.4	103.2
Nov. 23	75	82	101.9	102.8	105.3	103	101.7	102.7	103.2	104	102.5	103.6
Nov. 24	76	78	102	102.1	102	103	101.5	101.8	103.4	103.2	102.3	103.2
Nov. 25	78	82	102	102.2	103	103.8	101.6	102.5	104	103.6	103.5	104
Nov. 26	80	77	101.9	102	104	104.6	101.7	101.2	102.8	102.6	103.7	103.8
Nov. 27	75	....	101.6	....	103	....	101.8	....	102.2	....	102.7	....
Nov. 28	72	80	101.7	101.7	103.5	104	100.8	101.8	102	101.7	102.6	102.7
Nov. 29	72	80	101.5	101.9	102.5	103.5	101	102	102.1	102.5	102	103
Dec. 1	76	78	101.7	102.5	102.5	103	101.6	102.4	102	103	102.1	103.2
Dec. 2	72	74	101.7	101.7	102.8	103	101.5	102.4	101.5	102.5	102.2	102.8
Dec. 3	78	78	101.8	102.2	103.4	103	102	103.2	103	102.5	102.4	103.4
Dec. 4	74	77	101.4	101.5	102.2	102.8	103	105.2	101.6	101.9	101.5	102.6
Dec. 5	78	77	101.8	102	102.9	104.2	104.1	106	102.6	102.8	102.2	103
Dec. 6	76	80	101.6	103	102.2	103.4	102.4	103.2	101.8	102.7	102.6	103
Dec. 7	76	74	101.5	101.5	103.2	103.2	100.2	101	102.4	102.2	103	102.9
Dec. 8	71	74	101.5	102.5	102.9	102.6	100.4	101.2	101	102.2	102	101.5
Dec. 9	76	76	101.8	101.8	102.5	102.5	101.2	101.5	107	107	102	102.6
Dec. 10	75	78	101.7	102.3	102.2	103.5	101.2	102.2	101.2	102	102	103
Dec. 11	70	70	101.8	101.8	102.5	103.5	100.8	101.6	101.7	101.7	102	101.8
Dec. 12	62	....	102	....	102.2	....	101.5	....	102.1	....	101.8	....

Animals in stable artificially heated, 1890—Continued.

Date.	Temperature of stable.		117.		130.		145.		152.	
	Morning.	Evening.	Morning.	Evening.	Morning.	Evening.	Morning.	Evening.	Morning.	Evening.
Dec. 12	....	64	....	101.6	....	102.3	....	103.4	....	102.2
Dec. 13	68	67	101.7	101.8	103.8	103.4	101.4	102.4	102.4	103.3
Dec. 14	71	....	101.9	....	103	....	101.5	....	102.5	....
Dec. 15	72	76	101.2	101.9	102.5	102.6	101.8	101.8	102	102.4
Dec. 16	69	74	101.8	103	101.9	102.4	101.7	102.2	102.6	103.2
Dec. 17	74	74	103.4	102	101.9	101.8	102.2	101.8	103.2	103.2
Dec. 18	69	71	101	102.4	101.5	102	101.3	102	101.6	102.7
Dec. 19	69	72	101.6	102	102	101.8	101.5	101.7	101.7	101.8
Dec. 20	68	71	101.6	102	101.4	101.5	101.8	101.5	101.5	101.8
Dec. 22	72	78	101.6	102.5	101.5	101.8	101.5	102	102.4	102
Dec. 23	71	74	102.5	102.2	101.4	101.6	101.2	101.6	102.6	102.6
Dec. 24	68	70	101.7	102.1	101.5	101.5	101.8	102	101.4	102.2
Dec. 25	72	....	102.4	....	101.8	....	101.8	....	102.2	....
Dec. 26	72	64	102.2	102.3	104.7	104.4	101.6	102	102.2	101.8
Dec. 27	70	72	102	103.1	102.2	105	101.6	101.5	102.5	103.8
Dec. 28	76	76	102.2	102.8	104.5	106.4	101.4	102.1	103.7	105.4
Dec. 29	74	77	101.7	102.5	106.3	105.8	101.2	102	105.4	106.3
Dec. 30	70	83	102.2	103.6	105.6	105.7	102.2	101.8	105.2	104.8
Dec. 31	72	80	102.4	....	105.3	105.6	101.5	....	101.2	105.4
Jan. 1	74	80	102.2	....	103.8	104.2	101	....	101.4	104.5
Jan. 2	81	84	102.8	103	101.7	102.6	101.6	101.8	102	102.5
Jan. 3	67	76	101	101	101.2	101.7	100.8	101	103.2	102.7
Jan. 4	74	76	101.5	102.4	101.8	102.2	101.6	101.7	102.4	103.2
Jan. 5	70	70	101.2	102	101	102.2	101.2	101.6	103	104.3
Jan. 6	70	75	101	102	101.7	102.5	101.5	101.8	102.2	102.6
Jan. 7	64	73	101.4	101.8	101.2	102	101.4	101.7	102.2	102.2
Jan. 8	72	78	101.2	102.3	102.5	103	101.4	102	101.6	102.8
Jan. 9	72	78	101.5	102.6	103.2	104	101.6	102.2	101.6	101.8
Jan. 10	74	80	101.5	103	102.5	103	101.4	102.6	101.8	102.5
Jan. 11	78	....	103.2	....	102.8	....	102.4	....	102.2	....
Jan. 12	80	....	102	....	101.7	....	102.6	....	101.6	....
Jan. 13	72	74	101.4	102	101.6	103	101.2	101.8	101.5	101.7
Jan. 14	73	81	101.5	102.3	101.8	102.5	102.8	103.5	101.6	102.2
Jan. 15	80	81	101.6	102.2	101.5	101.8	101.2	102	102.5	101.8
Jan. 16	78	82	102.2	102.3	101.5	101.8	101.5	103	102	102.6
Jan. 17	76	78	102.2	103.2	101.4	102	102	103.4	102	101.8
Jan. 19	76	74	101.3	102.6	101	101.6	103.2	104	101.8	101.7
Jan. 20	79	78	101.2	101.8	101.2	102	103	104.5	102.4	102.6
Jan. 21	72	76	100.7	102	101.4	101.8	103.9	105.2	102.2	102
Jan. 22	78	78	101.5	102	102.2	102.6	104.4	105	101.3	102
Jan. 23	74	80	101.4	102.6	101.7	101.8	104	104.5	101.6	102.2
Jan. 24	72	70	101.8	102	101.2	101.6	104	105	101.6	102.3
Jan. 25	58	68	101.4	102.5	101.5	101.4	104	104.8	100.6	101.6
Jan. 26	67	70	101	101.4	101.2	101.5	103.7	104	101.5	101.4
Jan. 27	62	72	101.7	102.5	101.4	102.2	104	104.5	101	101.8
Jan. 28	66	76	101.6	101.8	101.8	101.6	103.8	104.3	101	101.5
Jan. 29	72	75	101.2	101.6	101.5	101.8	103.8	104	101.3	101.4
Jan. 30	71	72	101.2	102.2	101.4	101.7	103	103.6	101.5	101.5
Jan. 31	65	74	101.8	102.5	101.3	101.7	102.4	103.8	103.4	101.6
Feb. 2	72	....	101.4	....	101.3	....	102.4	....	101.5	....
Feb. 3	72	76	101.2	102	101	101.4	102.2	102.8	101.4	101.5
Feb. 4	60	70	101.2	102	100.8	101.5	101.8	103	100.5	101.6
Feb. 5	68	70	101.7	102	101.6	101.6	102.4	102.6	101.7	101.4
Feb. 6	75	70	102.2	101.8	101.5	101.8	102	102.6	101.7	102
Feb. 7	64	70	101.4	102.4	101	101.6	101.8	102.2	101.6	101.5
Feb. 9	68	70	101.8	102	101	101.4	102	102.8	101.8	101.5
Feb. 10	65	73	100.8	102.4	101.4	101.3	101.4	102.2	101	101.8
Feb. 11	68	76	101.6	102.6	101	101.6	101.7	102.4	102	101,8
Feb. 12	70	68	101.2	102	101.2	101.6	101.4	101.4	101.5	101.8
Feb. 13	71	72	101.4	102	101.8	101.7	102.4	102.6	101.6	101.6
Feb. 14	69	72	101.5	102.2	101.5	101.8	102	102.6	101.7	102
Feb. 16	71	72	101.8	102.2	101.4	101.6	101.2	101.5	101.6	102
Feb. 18	73	....	101.5	....	101.8	....	101.7	....	101.8	....
Feb. 19	60	70	100.6	102	101.4	101.8	101.3	102	101.7	102
Feb. 21	74	75	101.6	102.2	101.8	101.6	101.8	101.7	101.2	101.4
Feb. 23	68	....	101.6	....	101.4	....	101.8	....	101.3	....
Feb. 24	72	78	101.4	102	101.5	102	101.7	102	101.3	101.6
Feb. 26	70	74	101.5	102.2	101.6	101.6	101.2	101.8	101.2	101.5
Mar. 2	62	65	102	103	102.4	102.8	101.8	102.2	101.7	101.8
Mar. 5	60	66	102	101.6	101.4	101.2	101.5	101.6	101.4	101.5
Mar. 9	68	70	102	102	101.6	101.3	102.2	103.1	101.6	101.7
Mar. 12	69	68	101.2	101.6	101.5	102	101.6	102.6	101.8	102.1
Mar. 16	65	....	101.2	....	101.6	....	102.2	....	102.4	....
Mar. 21	65	70	101.6	101.5	102	101.6	101.5	101.6	101.8	102
Mar. 24	73	72	101.2	101.8	101.2	101.4	102	101.2	102	102
Mar. 28	63	70	101.2	101.4	101.4	101.4	102.4	101.8	101.8	101.8
Apr. 1	61	68	101.2	101.6	101.3	101.6	103	103.7	101.8	101.8
Apr. 4	63	64	101.4	102	101.8	101.4	102	101.8	101.7	103
Apr. 7	60	72	101.6	102.2	101.4	101.8	102.2	101.8	101.5	101.7

Field VI, 1891.

Number of animal.	55	56	62	102	104	121	126	130	143	159	163	169	60	181	105	184	160	187
Age of animal	5 yrs	4 yrs	3 yrs	7 yrs	4 yrs	4 yrs	6 yrs	6 yrs	2½ yrs	2 yrs	6 yrs	8 yrs	6 yrs	2½ yrs	3 yrs	2 yrs	2½ yrs	4 mos.
Date of exposure	July 2	July 2	July 2	July 2	July 2	July 2	July 2	July 2	July 2	July 2	July 2	Sept. 1	Sept. 1	Sept. 5	Sept. 5	Sept. 15	Sept. 21	Sept. 21
Result of exposure	Negative.	Recovered.	Negative.	Negative.	Recovered.	Negative.	Negative.	Died	Recovered.	Recovered.	Died	Died	Negative.	Died	Negative.	Died	Recovered.	Negative.
Died days after exposure.								56			54	13		14		17		
Aug. 6, 2.30 p. m	103.7	102.	103.7	102.1	104.3	103.	102.7	102.6	103.8	102.9	102.5							
Aug. 10, 10 a. m	103.3	102.2	103.7	103.7	104.4	103.	102.8	103.	104.	104.1	103.8							
Aug. 13, 10 a. m	102.3	101.6	102.1	101.8	102.2	102.4	102.	102.5	102.8	102.7	102.3							
Aug. 18, 11 a. m	102.4	101.6	102.	101.8	105.6	101.5	102.2	101.8	103.8	102.2	102.							
Aug. 21, 11 a. m	101.8	102.5	101.6	101.4	106.2	101.2	101.5	102.	107.	101.8	101.1							
Aug. 24, 10 a. m	101.5	105.8	101.8	100.8	104.5	100.8	101.5	105.6	107.	106.9	106.8							
Aug. 26, 9:30 a. m	101.5	106.8	101.4	101.4	99.8	101.6	101.6	106.7	103.5	105.4	Dead							
Aug. 27, 10:30 a. m	102.1	107.	101.8	102.4	100.6	102.	101.8	100.6	101.7	105.2								
Aug. 29, 1 p. m	102.5	103.8	101.8	101.8	100.3	101.2	102.	Dead	102.2	102.8								
Aug. 31, 10 a. m	102.3	102.8	101.	101.8	101.6	101.6	101.2		104.	101.8								
Sept. 2, 9.30 a. m	101.3	101.7	101.6	101.2	101.	101.4	101.		104.	101.8		100.8	101.5					
Sept. 4, 11 a. m	103.	103.2	102.2	102.8	104.2	102.5	102.		102.6	103.8		105.	102.4					
Sept. 5, 10 a. m	102.4	101.8	101.2	101.	100.8	101.2	101.6		101.2	101.5		101.4	101.7					
Sept. 7, 9.30 a. m	102.2	101.8	101.4	101.4	101.6	101.8	101.6		101.2	101.8		101.2	101.6	102.	102.			
Sept. 9, 9.30 a. m	101.8	100.3	101.8	101.2	101.8	101.6	102.		101.5	101.4		102,6	101.5	101.8	101.4			
Sept. 11, 10 a. m	101.4	101.2	101.	101.4	100.7	101.2	101.		101.5	101.4		104.6	101.2	101.6	101.2			
Sept. 12, 9 a. m	101.8	101.2	101.	100.6	100.8	101.6	101.7		101.8	101.		103.4	101.	101.	101.7			
Sept. 14, 10 a. m	101.6	102.	101.8	101.6	101.4	101.5	101.6		101.3	101.8		Dead	101.4	102.5	101.5			
Sept. 16, 10 a. m	102.	101.8	101.8	103.6	102.5	102.	101.5		102.6	102.2			101.7	106.4	102.2	103.5		
Sept. 19, 9 a. m	101.4	101.5	102.	101.	101.4	101.8	101.4		102.2	101.8			101.2	Dead	102.	100.8		
Sept. 21, 10 a. m	100.8	101.8	101.2	101.	100.4	101.4	101.5		101.2	101.4			101.2		101.5	100.5		
Sept. 23, 10 a. m	101.2	101.6	101.5	102.	101.	101.8	101.4		101.6	101.8			101.2		101.6	100.5	102.2	102.
Sept. 25, 10 a. m	101.3	101.5	101.4	101.2	101.	102.5	101.2		102.	102.			101.2		102.	101.6	102.2	101.8
Sept. 28, 9 a. m	101.7	101.2	101.	101.	102.2	101.5	101.2		101.8	101.			101.2		102.2	107.	101.8	101.8
Sept. 30, 10 a. m	101.4	102.	101.4	100.6	101.	101.2	101.5		101.8	102.			100.8		102.	105.5	102.	
Oct. 3, 10 a. m	101.4	101.4	101.6	100.8	100.	101.6	101.2		101.2	100.8			100.5		101.8	Dead	102.2	
Oct. 5, 10 a. m	101.8	102.	102.	101.5	102.5	101.6	101.5		102.	102.2			101.8		102.2		106.	
Oct. 8, 11 a. m	102.2	101.2	101.2	101.8	102.4	101.6	101.2		102.	102.6			101.		101.8		105.	
Oct. 10, 10 a. m	101.8	101.5	101.5	100.6	100.2	101.	100.8		101.	101.2			100.8		101.6		104.	
Oct. 12, 9 a. m																	101.	

Field XI, 1891.

No. of animal	161	164	167
Age of animal	6 years	7 years	3½ years.
Date of exposure	July 2	July 2	July 2.
Result of exposure	Negative	Died	Recovered.
Aug. 6, 2 p. m	102. 3	101. 9	102. 1
Aug. 10, 10 a. m	103. 3	103. 6	103. 2
Aug. 13, 10 a. m	101. 8	102. 4	102. 2
Aug. 18, 10 a. m	102. 2	102	101. 5
Aug. 21, 9 a. m	102. 2	102	101. 8
Aug. 24, 7 p. m	101. 8	104	101. 6
Aug. 25, 2 p. m	102. 2	106. 5	101. 4
Aug. 26, 9 a. m	102. 2	106. 2	102. 2
Aug. 27, 11 a. m	101. 9	106. 6	101. 8
Aug. 28, 9 a. m	101. 8	106. 5	104. 2
Aug. 29, 12 m	101. 8	105. 8	104. 8
Aug. 31, 10 a. m	101. 8	102	107. 2
Sept. 1, 2 p. m	102		106. 8
Sept. 2, 9 a. m	102	98	106. 8
Sept. 4, 10 a. m	102. 4	Dead.	104. 8
Sept. 5, 10 a. m	102		102. 8
Sept. 7, 9 a. m	101. 4		103. 7
Sept 9, 9 a. m	101. 6		105
Sept. 11, 9 a. m	102. 8		192 6
Sept. 12, 8 a. m	101		100. 6
Sept. 14, 8 a. m	101		100. 8
Sept. 16, 8 a. m	102		100. 8
Sept. 19, 8 a. m	102. 5		101. 6
Sept. 21, 9 a. m	102		101. 8
Sept. 23, 8 a. m	101. 8		102
Sept. 25, 8 a. m	101. 2		101. 8
Sept. 28, 8 a. m	102. 4		101. 2
Sept. 30, 8 a. m	102. 2		100. 2
Oct. 3, 9 a. m	103. 2		100. 8
Oct. 5, 11 a. m	101		100. 8
Oct. 8, 11 a. m	102		103
Oct. 10, 8 a. m	101		101. 8

Intravenous injection of infusion of ticks, 1891.

No. of animal	165		183.	
Age of animal	2½ years		2½ years.	
No. of field	IV		IV.	
Date of inoculation	Aug. 29		Aug. 29.	
Result of inoculation	Negative		Negative.	
	Morning.	Evening.	Morning.	Evening.
Aug. 29		102. 2		103. 2
Aug. 30	100. 6	102. 3	100. 6	102
Aug. 31	101. 2	102. 6	101	102. 3
Sept. 1	101. 3	103	101. 3	102. 3
Sept. 2	100. 8	102. 6	101. 2	102. 6
Sept. 3	101. 4	103. 4	101. 1	101. 7
Sept. 4	101. 4	103	100. 5	101. 8
Sept. 5	101	103. 2	101. 2	101. 8
Sent. 6	102. 3		101	
Sept. 7	101. 6	103	100. 6	102
Sept. 8	101. 2	102. 9	100. 7	102
Sept. 9	101. 6	103. 2	101. 2	101. 8
Sept. 10	101. 2	102. 8	100. 8	101. 6
Sept. 11	101. 1	104	101	101. 8
Sept. 12	101. 4	105	101	101. 6
Sept. 13	100. 8	103	100. 6	101. 8
Sept. 14	101. 2	103	100. 8	101. 6
Sept. 15		103. 6		102. 2
Sept. 16		103. 5		102. 6
Sept. 17		104		101. 6
Sept. 18	102. 6	103. 6		102
Sept. 19		104. 2		102
Sept. 21		103. 4		101. 5
Sept. 22		104. 9		103
Sept. 23		104. 5		102. 2
Sept. 24		103. 4		101. 2
Sept. 25		103		101. 2
Sept. 26		103. 8		102
Sept. 28		103. 4		101. 2
Sept. 30	100. 6		100. 4	
Oct. 3	102		101. 4	
Oct. 5		102. 4		101
Oct. 7	101. 6		102	

Intravenous injection of Texas fever blood. Field II. 1891.

Number of animal	182		185		186.	
Age of animal Date of inoculation Result of inoculation	3½ years. September 19. Recovered.		7 years. September 19. Recovered.		10 to 12 years. September 19. Died.	
	Morning.	Evening.	Morning.	Evening.	Morning.	Evening.
September 20	100.9		100.8		100.8	
September 21	100	102.4	100	102.2	100	103
September 22	100.6	102.8	102	105.6	100.4	103.4
September 23	102.2	102.2	102.4	104.8	102.6	104.7
September 24	100.5	102.2	105.5	106.4	101.6	105
September 25	100.8	105.4	106.4	107	104.3	105.8
September 26	101.7	104.6	105.8	106.2	106	106.4
September 27	104.8	106.4	104.5	105.8	104.6	105.8
September 28	105.6	106.8	102.3	104	102.2	Dead.
September 29	106.2	106.6	101.2	102.7		
September 30	104.7	105.7	100	102.3		
October 1	102	105.3	100.2	103.2		
October 2	102.6	104.2	100.8	102		
October 3	102.4	105	101.4	104.5		
October 4	101	105.4	101.2	104.9		
October 5	102.2	105.2	102	104.4		
October 6, 8 a. m	101.8		100.5			
October 7, 1 p. m	101.5		102.4			
October 8, 1 p. m	101.4		104.8			
October 9, 4 p. m	103		100.4			
October 10, 12 m	100.6		99.6			
October 12, 8 a. m	100.2		99.4			
October 13, 10 a. m	100.2		99.6			
October 14, 4 p. m	101.2		102.6			
October 15, 4 p. m	101.6		102.2			
October 17, 9 a. m	100.8		100			

Fields IV and VI, 1892.

No. of animal	201	203	135	167	220	223	56	105	160	166	182	185	204	225
No. of field	VI–IV	VI	VI	VI	VI	VI	VI	VI	VI	VI	VI	VI	VI	VI
Age of animal	5 years	6 years	4 years	4½ years	2½ years	6 years	5½ years	4 years	3 years	3 years	4½ years	8 years	2½ years	8 years
Date of exposure	June 30	June 30	July 20	July 20	July 20	July 20	Aug. 26	Aug. 26	Aug. 26	Aug. 26	Aug. 26	Aug. 26	Aug. 26	Aug. 30
Result of exposure	Negative	Died	Recovered.	Recovered.	Recovered.	Died	Recovered.	Recovered.	Negative	Negative	Slight attack.	Negative	Recovered.	Recovered.
July 2, 5 p. m.	103	103.2	......	......	......	......	......	......	......	......	......	......	......	......
July 3, 5 p. m.	102.2	102.8	......	......	......	......	......	......	......	......	......	......	......	......
July 4, 5 p. m.	102.3	102.3	......	......	......	......	......	......	......	......	......	......	......	......
July 6, 5 p. m.	102.4	103.2	......	......	......	......	......	......	......	......	......	......	......	......
July 8, 5 p. m.	102.2	102.4	......	......	......	......	......	......	......	......	......	......	......	......
July 9, 5 p. m.	101.6	102.2	......	......	......	......	......	......	......	......	......	......	......	......
July 10, 5 p. m.	102	102	......	......	......	......	......	......	......	......	......	......	......	......
July 11, 5 p. m.	102	102.2	......	......	......	......	......	......	......	......	......	......	......	......
July 12, 5 p. m.	102.2	102.8	......	......	......	......	......	......	......	......	......	......	......	......
July 14, 5 p. m.	102.8	103.2	......	......	......	......	......	......	......	......	......	......	......	......
July 16, 5 p. m.	102.4	101.8	......	......	......	......	......	......	......	......	......	......	......	......
July 18, 5 p. m.	101.8	102	......	......	......	......	......	......	......	......	......	......	......	......
July 20, 5 p. m.	*102.5	103	105.4	103	103.8	102.8	......	......	......	......	......	......	......	......
July 23, 5 p. m.	102.2	105	106.4	103.8	105.5	105.2	......	......	......	......	......	......	......	......
July 25, 5 p. m.	103.8	105.4	107	104.3	105.2	104.4	......	......	......	......	......	......	......	......
July 27, 8 a. m.	101.6	102.8	104	102.2	103.8	102	......	......	......	......	......	......	......	......
July 27, 5 p. m.	103.6	105.4	105.8	103.6	105.8	104.2	......	......	......	......	......	......	......	......
July 28, 8 a. m.	101	101	102.6	101.5	101.6	100.7	......	......	......	......	......	......	......	......
July 29, 8 a. m.	101	102.8	103	102.4	103.1	102	......	......	......	......	......	......	......	......
July 29, 5 p. m.	103.6	104	105.8	103.2	104.2	103.5	......	......	......	......	......	......	......	......
July 30, 8 a. m.	102	102.2	102.8	101.8	102.2	102.4	......	......	......	......	......	......	......	......
July 30, 5 p. m.	103.8	104.6	106	103	104.8	104.2	......	......	......	......	......	......	......	......
Aug. 1, 8 a. m.	102.2	101.2	102	101.7	101.8	101.8	......	......	......	......	......	......	......	......
Aug. 1, 5 p. m.	102	102.6	105.2	102.8	104.8	102.2	......	......	......	......	......	......	......	......
Aug. 3, 8 a. m.	101.8	102.3	102	102.2	101.8	101.8	......	......	......	......	......	......	......	......
Aug. 3, 5 p. m.	102.2	102.2	105.5	102.5	104.8	104.2	......	......	......	......	......	......	......	......
Aug. 5, 8 a. m.	101.7	101.7	101.5	101.8	101.8	102	......	......	......	......	......	......	......	......
Aug. 5, 5 p. m.	102.5	102	104	102	103.8	102.5	......	......	......	......	......	......	......	......
Aug. 6, 8 a. m.	101.8	101.8	101.2	101.5	101.6	101.7	......	......	......	......	......	......	......	......
Aug. 6, 5 p. m.	102	102	104	102.2	104.4	102, 5	......	......	......	......	......	......	......	......
Aug. 8, 8 a. m.	101.6	102	103.2	102.8	102.2	102	......	......	......	......	......	......	......	......
Aug. 8, 5 p. m.	102.3	102.8	105.2	102.8	105.2	102.2	......	......	......	......	......	......	......	......
Aug. 10, 8 a. m.	102.2	102	102.4	102.8	102.2	102.4	......	......	......	......	......	......	......	......
Aug. 10, 5 p. m.	102.1	103.2	105.4	103.5	105	102.6	......	......	......	......	......	......	......	......
Aug. 12, 8 a. m.	102.1	101	101	101	101.4	101.3	......	......	......	......	......	......	......	......
Aug. 12, 5 p. m.	101.9	101.9	103.3	102.2	103.6	102	......	......	......	......	......	......	......	......

*Transferred to field IV.

Fields IV and VI, 1892.

No. of animal	201	203	135	167	220	223	56	105	160	166	182	185	204	225
No. of field	VI-IV	VI	VI	VI	VI	VI	VI	VI	VI	VI	VI	VI	VI	VI
Age of animal	5 years	6 years	4 years	4½ years	2½ years	6 years	5½ years	4 years	3 years	3 years	4½ years	8 years	2½ years	8 years
Date of exposure	June 30	June 30	July 20	July 20	July 20	July 20	Aug. 26	Aug. 26	Aug. 26	Aug. 26	Aug. 26	Aug. 26	Aug. 26	Aug. 30
Result of exposure	Negative	Died	Recovered.	Recovered.	Recovered.	Died	Recovered.	Recovered.	Negative	Negative	Slight attack.	Negative	Recovered.	Recovered.
Aug. 13, 8 a. m.	101.4	101.4	101	101.2	101.2	101.6	......	......	......	......	......	......	......	......
Aug. 13, 5 p. m.	102	102.8	102.9	102.8	103.8	102.2	......	......	......	......	......	......	......	......
Aug. 15, 8 a. m.	101.4	101.6	101.5	101.6	101.8	102.4	......	......	......	......	......	......	......	......
Aug. 15, 5 p. m.	102.2	103.8	104.7	102.2	105.4	103.8	......	......	......	......	......	......	......	......
Aug. 16, 8 a. m.	101	102	101.2	101.4	101.8	105.8	......	......	......	......	......	......	......	......
Aug. 16, 5 p. m.	101.6	105.2	104.3	102.6	104.4	105.4	......	......	......	......	......	......	......	......
Aug. 18, 8 a. m.	101	104.6	100.4	101.4	104	104	......	......	......	......	......	......	......	......
Aug. 18, 5 p. m.	101.4	106.4	103	102.7	105.8	106.8	......	......	......	......	......	......	......	......
Aug. 20, 8 a. m.	100.8	107.6	100.8	102.4	107	107.2	......	......	......	......	......	......	......	......
Aug. 20, 5 p. m.	101.8	107.4	103.4	103.8	106.6	108.2	......	......	......	......	......	......	......	......
Aug. 22, 8 a. m.	100.8	100.3	100.8	102.2	107	106.2	......	......	......	......	......	......	......	......
Aug. 22, 5 p. m.	101.8	Dead	103.8	103.4	106.6	103.8	......	......	......	......	......	......	......	......
Aug. 24, 8 a. m.	101.1	......	100.8	103.1	105.2	Dead	......	......	......	......	......	......	......	......
Aug. 24, 5 p. m.	101.4	......	102.2	104	105.2	......	......	......	......	......	......	......	......	......
Aug. 26, 8 a. m.	100.8	......	101.2	102.8	105.6	......	......	......	......	......	......	......	......	......
Aug. 26, 5 p. m.	101.5	......	103.8	102.8	105.6	......	101.6	101.8	101.8	102.2	102.4	102	102.8	......
Aug. 29, 8 a. m.	100.8	......	100	100.8	100.2	......	100.8	100.4	101.5	100.2	100	101.5	101.5	......
Aug. 29, 5 p. m.	101.2	......	101.4	102	102.4	......	100.4	101.6	102.8	101	102.2	101.8	103	......
Aug. 31, 8 a. m.	100.8	......	101	101.3	100.7	......	101.4	101.2	101.4	100.6	101.6	101.5	100	101
Aug. 31, 5 p. m.	101	......	102.2	102.2	102.4	......	101.8	101.7	101.7	102	102.6	102.6	102.2	100.8
Sept. 2, 8 a. m.	100.2	......	101.4	101.6	102.4	......	101.4	101.4	101.3	101.4	100	101.4	101.4	101.6
Sept. 2, 5 p. m.	102	......	103.6	102.8	106	......	101.8	101.6	101.8	102	102.2	102.6	102.8	102.2
Sept. 5, 8 a. m.	100	......	100.4	100.8	100.6	......	100.8	100.8	100.6	100.6	100.2	100.6	102.8	100.8
Sept. 5, 5 p. m.	101.6	......	104.2	103	102.6	......	101.8	102.4	102.4	101	102.4	162.6	105.4	101.6
Sept. 8, 8 a. m.	101	......	100.8	101.2	102.4	......	100.8	101.2	101.5	101	101.2	101.8	106	100.8
Sept. 8, 5 p. m.	101.8	......	103.2	102.7	104.5	......	101.2	102	101.7	102.2	102.8	103.	107.4	102.4
Sept. 10, 8 a. m.	101.4	......	101	101.4	101.4	......	101.2	101.4	101.5	101.8	101.4	101.6	107.6	101.6
Sept. 10, 5 p. m.	101.6	......	102.2	102	101.8	......	101.4	101.4	101.8	101.8	103	102	107	101.4
Sept. 12, 8 a. m.	101	......	100.6	101.8	100.2	......	101.5	101.2	101.2	101.8	101.5	102.2	104.8	101.2
Sept. 12, 5 p. m.	102	......	102.2	102.4	102.4	......	101.8	101.6	102	102.2	103.2	103.6	105.6	102.5
Sept. 14, 8 a. m.	101.2	......	101.6	101.5	101.2	......	101.5	104	102	101.6	102.2	101.5	104	102.4
Sept. 14, 5 p. m.	102	......	104	101.4	102.8	......	101.2	105.2	101.6	101.4	103.8	102.8	104.6	104.6
Sept. 16, 8 a. m.	100.8	......	101.2	100.8	100.2	......	101	100.2	101.8	100.8	103.6	101.6	100.5	101
Sept. 16, 5 p. m.	101.8	......	102.6	102.5	103	......	101.4	101.2	102	102.2	105.8	102.5	103.4	101.5
Sept. 19, 8 a. m.	101.2	......	101.6	102.2	101.6	......	101.1	101.2	100.8	101.2	102.2	101.6	101.8	104.4
Sept. 19, 5 p. m.	101.2	......	101.8	102.2	102.6	......	101.4	102	101	101.5	104.2	102	101.8	104
Sept. 23, 8 a. m.	101	......	101	101.8	100.8	......	101	101.6	101	101.5	100.4	101.2	100.7	100.6
Sept. 23, 5 p. m.	101.5	......	104.7	103.2	102.8	......	104.6	102.6	101.8	103	103	102.6	102.5	102.8

Fields I and II, 1892.

No. of animal	208		209		205		210	
Age of animal No. of field Date of exposure Result of exposure	5 years I July 2 Negative		9 years I July 2 Negative		5 years II July 2 Negative		2 years. II. July 2. Negative.	
	8 a. m.	5 p. m.	o a. m.	5 p. m.	8 a. m.	5 p. m.	8 a. m.	5 p. m.
July 2	....	102.8	....	103.4	....	102.6	....	102.5
July 3	....	102.4	....	103	....	103	....	102.8
July 4	....	101.6	....	102.4	....	102.8	....	102.8
July 6	....	102	....	102.5	....	102.2	....	102.8
July 8	....	102	....	103	....	102.1	....	102
July 9	....	103.5	....	102.5	....	102	....	101.2
July 10	....	102	....	101.8	....	101.8	....	102
July 11	....	102	....	102	....	102	....	102.2
July 12	....	101.8	....	102.2	....	101.8	....	102.2
July 14	....	101.8	....	103	....	102	....	102.2
July 16	....	101.8	....	102	....	103.2	....	102
July 18	....	101.8	....	102.2	....	101.8	....	102.3
July 20	....	102	....	101.8	....	101.5	....	102.2
July 23	....	102.6	....	106.2	....	101.2	....	103.2
July 24	101.8	102.4	102.3	103.4	....	....	....	....
July 25	102.2	102.6	102.2	104.8	....	102	....	103
July 26	101.6	103.2	102.2	104.2	....	....	....	....
July 27	102.4	103.4	102	104.8	101.4	101.8	101.5	102.4
July 28	102.2	102.6	101.2	103	101.8	....	101.2	....
July 29	102.7	102	102.5	103.6	102	101.8	102	102
July 30	102.2	102.5	103	103.8	102.4	102	102	102.2
Aug. 1	101.5	101.5	102.5	103.4	102	101.7	102	101.6
Aug. 3	101.6	101.8	102	103	102.2	102	101.2	102.6
Aug. 5	101.8	101.5	101.2	102.5	102	103.2	106.6	102.2
Aug. 6	101.8	102.2	101.2	102.5	101.9	102.2	101.5	101.2
Aug. 8	103.4	102	103.8	102.8	102.2	101.8	102.5	101.8
Aug. 10	102.4	102.5	102.5	102.6	102	102	101.8	101.6
Aug. 12	101.8	101.6	101.6	102.4	102.6	102	101.6	101.7
Aug. 13	101.8	101.9	101.4	101.9	101.4	104.2	101.4	101.8
Aug. 15	101.9	102	101.4	102.2	101.4	102.8	101.6	102.8
Aug. 16	101.5	101.4	101.4	102.4	101.8	101.2	101	102
Aug. 18	101.2	101.7	100.8	102.4	101.2	101.6	100.8	101.8
Aug. 20	101.6	102	101	102.6	101	101.4	101.4	101.8
Aug. 22	101	101.4	101	101.8	101.2	101.2	101	101.6
Aug. 24	101.5	100.6	101.7	101.5	101.3	101	100.8	101.2
Aug. 26	101	101.8	100.6	102.7	101.2	101.2	101	101.7
Aug. 29	101.2	101.4	101.4	101.4	100.8	101.2	101	101.2
Aug. 30	101.8	101.4	100	101.6	100.9	101.2	101	101.6
Sept. 2	101.6	102	101.2	101.6	100.8	100.8	100.4	101
Sept. 5	101	102.4	100.6	101.8	102.2	101.4	100	102
Sept. 8	101.4	102	101.2	101.8	101	102	100.8	102.4
Sept. 10	101.5	101.2	100.8	102	101.5	102.2	101.2	101.6
Sept. 12	101.2	101.8	101	102	101.2	102.4	101.4	101.5
Sept. 14	101.6	102	101.2	102.8	101.5	102.2	101	102
Sept. 16	100.8	101.5	100.6	102.2	101.2	102.3	100.4	101.8
Sept. 19	101	102.2	101	101.8	101.2	101.2	101.2	101.4
Sept. 23	101.2	102.4	100.6	101.8	101.2	102.2	100.5	101.8

Field III, 1892.

No. of animal	206		198		218		219		221		222		230	
Age of animal Date of inoculation Result	7 years July 6 Recovered		7 years July 6 Died		6 years July 16 (control) Negative		4 years July 16 Recovered		9 years August 15 (control) Negative		5 years August 15 Recovered		9 years. September 9.	
	8 a. m.	5 p. m.	8 a. m.	5 p. m.	8 a. m.	5 p. m.	8 a. m.	5 p. m.	8 a. m.	5 p. m.	8 a. m.	5 p. m.	8 a. m.	5 p. m.
July 2		102.5		103.2										
July 3		102.5		103										
July 4		102.6		102.4										
July 6		102.8		102.8										
July 7	101.2	102	102	104.3										
July 8	101.6	102.2	102.6	104.6										
July 9	101.2	102.2	102.2	104.8										
July 10	101	102	101.8	104										
July 11	101.2	101.6	101.5	102.6										
July 12	102.2	103	101.8	103										
July 13	103.8	104.2	106	106.4										
July 14	104.5	106.2	101.6	105.8										
July 15	107.4	106.8	104.5	103.6										
July 16	104	106	106.5	106.8	103	102.2	103.2	103.5						
July 17	103	105.7	104.7	107	101	102.6	101.2	102.4						
July 18	105.6	107.2	105.2	106	102	102.4	101.4	103						
July 19	104.6	106.8	101.8	Dead.	101.2	102.6	100.8	102.5						
July 20	105.4	106.4			102	103.4	102.6	104.2						
July 21	105.4	105.5			101.2	102.5	101.5	104						
July 22	105	105.2			102	102.4	102.2	105.4						
July 23	104.6	105.6			101.7	103.8	102.6	105.4						
July 24	104.8	105.4			102.2	103	107.5	105.8						
July 25	104.4	104.4			102.5	103	104.8	107.4						
July 26	103.5	103.7			102.4	103.2	105.8	107.4						
July 27	104.3	104.8			102.4	103	106.8	105.4						
July 28	105.6	105.2			101.3	102.8	106.5	106						
July 29	105.4	104.2			104.8	103	105.2	106.8						
July 30	103	104			103.2	103.4	105.4	106						
July 31	103				102.5		107							
August 1	102.2	102.2			101.8	101.9	105.4	106.2						
August 2	101.7	103			101.4	102.4	102.6	105						
August 3	102	103			101.8	102.8	102.8	105						
August 4	101.7	103			102.2	102	103	104						
August 5	102.6	103.2			102	101.8	101	104						
August 6	101.4	102.8			101.8	101.6	102	103.6						
August 8	104	103.5			103.2	102	103.8	104.5						
August 9	104.2	103.6			102.5	102.2	102.5	103.8						

Field III, 1892—Continued.

No. of animal	206		198		218		219		221		222		230	
	8 a.m.	5 p.m.	8 a.m.	5 p.m.	8 a.m.	5 p.m.	8 a.m.	5 p.m.	8 a.m.	5 p.m.	8 a.m.	5 p.m.	8 p.m.	5 p.m.
August 10	106.2	105.2	.....	.....	103	103	102.8	104.6	.....	.....	.....	.....	.....	.....
August 11	102.6	105	.....	.....	101.8	101.8	102.2	104	.....	.....	.....	.....	.....	.....
August 12	102	104	.....	.....	102	102	102	102.8	.....	.....	.....	.....	.....	.....
August 13	105	103.4	.....	.....	102	102	101.4	102.8	.....	.....	.....	.....	.....	.....
August 15	101.4	102.4	.....	.....	102	101.8	101.6	103.4	102.4	102	102.6	102.8	.....	.....
August 16	101.2	102.8	.....	.....	101.8	101.8	101.4	102.8	101.6	101.6	101.4	102.4	.....	.....
August 17	100.4	102	.....	.....	101	101.8	100.7	103.4	101.2	102.4	100.8	103.2	.....	.....
August 18	103.4	101.8	.....	.....	101.2	102	101.2	104.8	101	102.4	100.8	106.2	.....	.....
August 19	101.2	101.4	.....	.....	101.6	102	101.4	102.4	101	102.2	101.2	103.3	.....	.....
August 20	102.6	103.8	.....	.....	101.8	102.2	101.6	105.6	101.2	102.4	103	104.6	.....	.....
August 22	101.4	102.9	.....	.....	100.8	101.5	101	105.2	101	101.4	101.4	105.8	.....	.....
August 23	100.6	101.9	.....	.....	101.2	101.4	101.8	105.2	100.8	101.2	101	102.9	.....	.....
August 24	101.2	101.9	.....	.....	100.8	101	101.4	103.8	100.8	101.5	103.6	105.2	.....	.....
August 25	101.4	103	.....	.....	100.6	101.7	102.3	104.8	101.2	101.6	105	106.2	.....	.....
August 26	102.4	101.4	.....	.....	101	101.6	102.8	104.8	101	101.8	105.4	107.2	.....	.....
August 29	105.2	101.4	.....	.....	102	101	102.5	105.6	101.4	101.8	100.4	107.4	.....	.....
August 31	103	104.8	.....	.....	100.8	101.3	102.9	104.2	101	102	102.8	105.6	.....	.....
September 2	101.2	103.6	.....	.....	101.8	102	102.2	104.6	101.4	101.7	101.5	105.7	.....	.....
September 3	102.8	103.6	.....	.....	101.2	101.4	101.2	104.2	100.8	101.8	100.3	104	.....	.....
September 5	102.6	103.4	.....	.....	100.6	101.2	102	103.8	100.8	102.6	100	104.6	.....	.....
September 6	103.2	103.6	.....	.....	101.3	101.8	101.7	103.8	102	102.2	101.4	103.8	.....	.....
September 7	101.8	103.2	.....	.....	100.5	102.4	100	103.8	100.2	101.8	99	103.6	.....	.....
September 8	102.4	105	.....	.....	101.8	102.7	101	104.4	101.4	102.4	100	103.4	.....	.....
September 9	101.8	103.2	.....	.....	102	102	101.9	103.6	102.2	101.8	100.8	103	.....	102.5
September 10	102.2	104	.....	.....	101.3	102.5	101.8	103.6	101	102.2	100.5	102.8	100.8	101.8
September 12	102.2	102.2	.....	.....	101.8	102	101	104	101	102.2	100.8	103	100.5	101.4
September 13	104.5	101	.....	.....	101.4	102.2	101.2	101	101	101.5	100.8	101.2	100.6	100.8
September 14	102.2	104.4	.....	.....	101.8	102.8	102.5	105	102	103.8	101.8	104.3	103.8	105.8
September 15	101.8	103.2	.....	.....	102	102.2	102.8	104.8	102.1	102.5	102.5	103.2	103.8	106
September 16	102	105	.....	.....	101.4	102	101.5	104	101.2	102.2	101	103.2	105	106.4
September 17	102	102.8	.....	.....	102.2	101.8	102.6	104.8	101.8	102.5	101.5	103.5	105.2	107.2
September 19	100.8	102.8	.....	.....	101.2	101.2	102.8	104.2	101.2	101.2	102.6	103.8	104.8	105.8
September 21	101.2	103	.....	.....	101	102.2	102.5	103.8	101.2	102.5	101.2	104.4	104.2	104.6
September 23	101.4	102.2	.....	.....	101.6	102.2	100.2	104.2	100.8	102.4	100.8	103.2	102	105.8
September 24	101.5	103.4	.....	.....	101.5	102	101	103.8	101.7	102	101.2	104.2	103.2	104.8
September 28	101.6	102.6	.....	.....	101.8	102.5	102.5	104.5	101.8	102.8	101.6	105	101.5	104.2
September 30	100.8	101	.....	.....	101.6	101.4	101	103.2	101.6	101.5	101.2	106.6	101	103
October 3	101.5	102.5	.....	.....	101.8	102	101.2	103	101	101.8	100.6	103.8	99.8	103.6

Miscellaneous experiments, 1892.

No. of animal.	197		227		228		200		202		207	
Age of animals.	6 years		11 years		7 years		8 years		7 years		2 years.	
Number of field.	12A		12A		12A		12A		XIII		XIII.	
Date of inoculation.	Aug. 27		Aug. 27		Aug. 27		Aug. 30		Aug. 31		Aug. 31.	
Result of inoculation.	Died		Died		Recovered		Died		Negative		Negative.	
Died days after inoculation.	8		13		......		9		......		......	
	8 a. m.	5 p. m.	8 a. m.	5 p. m.	8 a. m.	5 p. m.	8 a. m.	5 p. m.	8 a. m.	5 p. m.	8 a. m.	5 p. m.
Aug. 29	101	101.6	100.8	102.4	100.8	101.6	......	......	......	......	......	......
Aug. 31	103.2	105	100.4	101.4	101.2	102	100.8	101.4	104	105	103.2	105
Sept. 2	105.4	106.6	100.6	104.8	100.8	106.6	100.6	100.2	100.8	101.8	101	101.3
Sept. 3	106.7	107.4	102.4	106.8	102.8	107	100.6	104.8	100.8	101.9	101.8	102
Sept. 5	Dead	Dead	103.8	106.8	103.6	106	101.2	105.4	101	101.4	101.4	102
Sept. 6	......	......	103	105.5	105.8	107.2	106	107.4	101	101.2	101.4	101.4
Sept. 7	......	......	103	103.6	106	108.1	105.2	107.5	100.8	102	100.4	102.4
Sept. 8	......	......	98.5	101	106	106.2	Dead	......	101.8	101.7	101.7	101.8
Sept. 9	......	......	97.5	102.8	104.2	105.8	......	......	101.8	101.7	101.2	102.2
Sept. 10	......	......	Dead	......	103.6	103.6	......	......	101.4	101.8	101.6	101.5
Sept. 12	......	......	......	......	102.8	105.8	......	......	101.6	102	101	101.8
Sept. 13	......	......	......	......	102.2	102	......	......	101.8	102.4	101.4	102
Sept. 14	......	......	......	......	102.1	105	......	......	101.5	101.8	101.8	101.8
Sept. 15	......	......	......	......	101.6	105	......	......	102.2	102	101.8	102
Sept. 16	......	......	......	......	101.6	104.5	......	......	101.4	102.4	101.2	101.8
Sept. 17	......	......	......	......	100.8	104.4	......	......	101.5	102	101.9	102.5
Sept. 19	......	......	......	......	101.7	105.2	......	......	102.4	101.4	101.6	101
Sept. 21	......	......	......	......	101.5	104.4	......	......	101.5	101.6	100.5	101.5
Sept. 23	......	......	......	......	100.8	103.5	......	......	101.2	101.8	100.8	101
Sept. 28	......	......	......	......	101	105	......	......	102	......	101.8	......
Sept. 30	......	......	......	......	100.6	103	......	......	......	......	......	......
Oct. 3	......	......	......	......	100.4	102.8	......	......	......	......	......	......

Miscellaneous experiments, 1892.

No. of animal	225		224	
Age of animal	8 years		11 years.	
Where placed	In stall		In stall.	
	8 a. m.	5 p. m.	8 a. m.	5 p. m.
Aug. 2	102.2	101.8	...	...
Aug. 3	101.2	102	...	...
Aug. 4	101.8	101.8	...	...
Aug. 5	101.8	101.5	...	...
Aug. 6	101	101.6	...	...
Aug. 8	101.2	102	...	...
Aug. 9	101.8	102.2	101.8	*104.5
Aug. 10	101.5	102.5	101.5	102.4
Aug. 11	101.6	102.2	102.2	102.2
Aug. 12	101.8	104	101.4	102
Aug. 13	102.4	104.4	101.4	101.7
Aug. 14	106	107.1	...	...
Aug. 15	107	100.1	101.6	102
Aug. 16	106.2	107.4	101.2	101.6
Aug. 17	105	106.8	101.2	102
Aug. 18	105.2	106.6	101.2	101.6
Aug. 19	104.2	105.5	101	102
Aug. 20	101.8	104	100.8	102.1
Aug. 21	100.8	101.6	101	102.4
Aug. 22	101.2	100.6	101.1	101.6
Aug. 23	101.4	102.3	101	101.2
Aug. 24	101.4	103.1	101.4	101.9
Aug. 25	102.2	102.4	101.6	103
Aug. 26	101.8	102.6	101	101.8
Aug. 29	101.2	102	101.4	102
Aug. 31	Transferred to field VI.		101.4	101.6
Sept. 2			101	101.4
Sept. 3	...	...	100.6	101.4
Sept. 5	...	...	101.2	101.8
Sept. 6	...	...	101.8	102.4
Sept. 7	...	...	101.8	106
Sept. 8	...	...	104.6	106.8
Sept. 9	...	...	105.8	106.6
Sept. 10	...	...	106.2	...
Sept. 12	...	...	104.2	106.8
Sept. 13	...	...	104.6	103.2
Sept. 14	...	...	104.6	105.2
Sept. 15	...	...	104.6	104.8
Sept. 16	...	...	103.8	104.6
Sept. 17	...	...	102.8	102.6
Sept. 19	...	...	101.8	103.4
Sept. 21	...	...	102.2	103.8
Sept. 23	...	...	102	103
Sept. 28	...	...	102.6	...

* High temperature perhaps due to the struggle necessary to get animal in stall.

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